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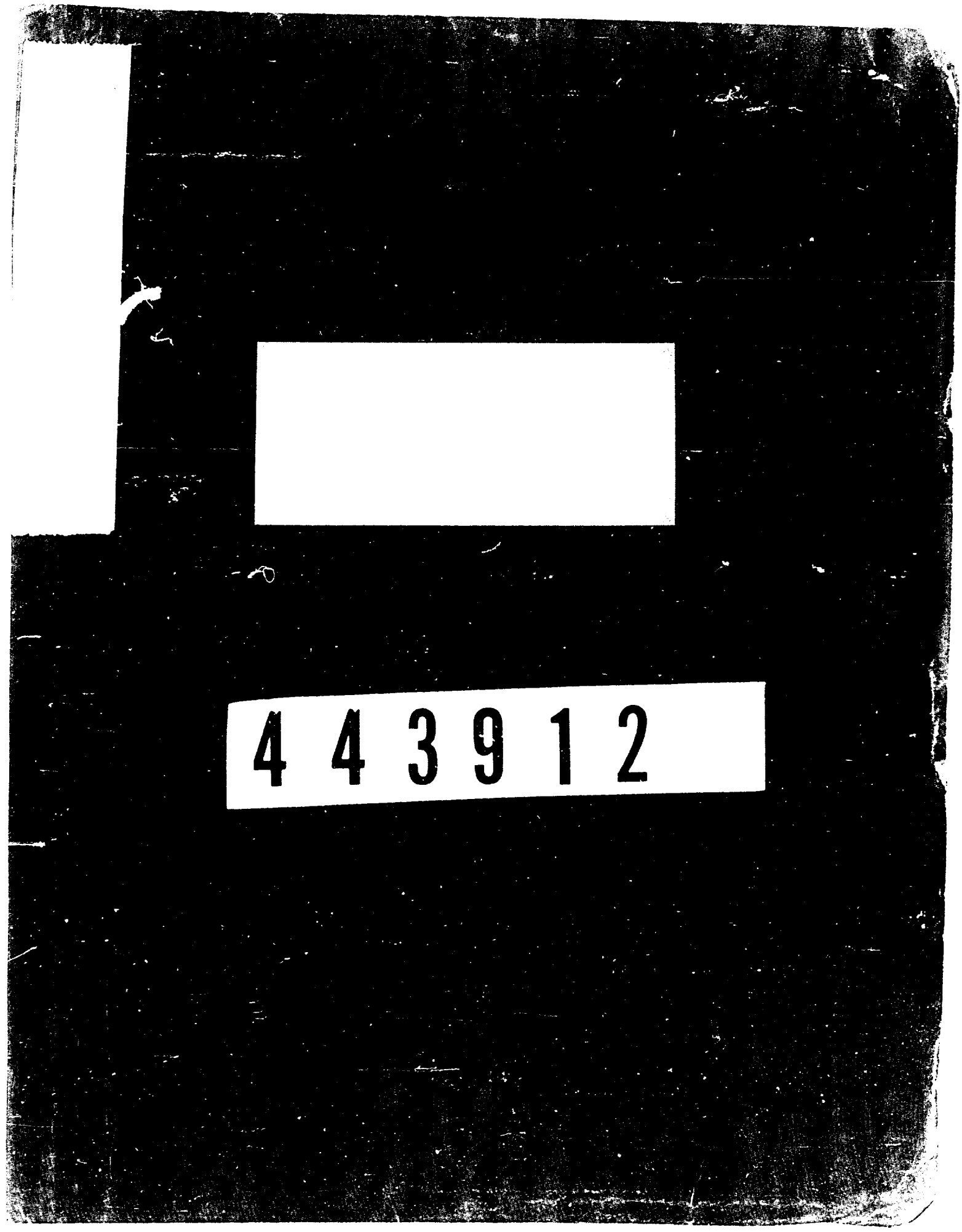
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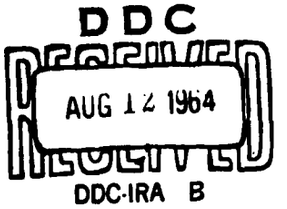

Keyword-In-Context (KWIC) Indexing:
Background, Statistical Evaluation, Pros and Cons, and Applications

Major Advisor: Dr. A. G. Holzman

Encouraged by among other things the "publish or perish" milieu of today, scientists, educators and researchers are a prolific lot, publishing technical literature in explosive proportions. The volume is such that machines have been called on to aid and expedite the processing and retrieval of information.

This thesis discusses keyword-in-context (KWIC) indexing, a new method of machine indexing literature. In presenting the subject, the author assumes that the reader is unfamiliar with the new discipline of Information Science, precipitated by the information explosion.

The background of machine indexing is developed deductively. Next, the author describes KWIC indexing, evaluates statistically the hypothesis upon which it is based (that titles are descriptive of the article or document they represent), lists its pros, cons and applications. And finally, the author concludes that KWIC indexing is indeed an efficacious new tool.

KEYWORD-IN-CONTEXT (KWIC) INDEXING:

BACKGROUND, STATISTICAL EVALUATION, PROS AND CONS, AND APPLICATIONS

by

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Master of Science

in

Industrial Engineering

University of Pittsburgh

1964

FOREWORD

Six months ago the author was first introduced to a keyword-in-context (KWIC) index. That the KWIC index was based upon the titles of documents rather than document contents seemed unusual, that it was produced by a computer, not a human, in minutes at a fractional cost seemed incredible and that there were individuals who doubted and even belittled the efficacy of this wonderous technique seemed perplexing. As time passed the author became more intrigued with KWIC indexing and finally decided to make it the subject of this his Masters thesis. Format-wise, the background of machine indexing in general is developed deductively. Next the author describes KWIC indexing, evaluates the hypothesis upon which it is based, lists its pros, cons and applications, and lastly draws conclusions. Furthermore, this complete investigation into KWIC indexing is basic in approach; it is written for the reader who is unfamiliar with the newly emerged discipline, Information Science.

ACKNOWLEDGEMENT

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I. BACKGROUND

A. Information Explosion

The importance of the availability of information to the scientific community has long been recognized. As early as 1852, Joseph Henry, secretary of the Smithsonian Institution reported to Congress:

> "...It is estimated that about twenty thousand volumes, including pamphlets, purporting to be additions to the sum of human knowledge, are published annually; and unless this mass be properly arranged, and the means furnished by which its contents may be ascertained, literature and science will be overwhelmed by their own unwieldy bulk. The pile will begin to totter under its own weight." (1)*

A half-century later, Henry Adams wrote of the law of acceleration of human knowledge, that if it were "prolonged one generation longer it would require a new social mind...subject to new laws."(2),(3)

World War II precipitated a massive increase in scientific research and a concomitant increase in scientific literature of all sorts. Noting the momentun of wartime research and its implications, Dr. Vannevar Bush, the great American scientist prophetically urged his colleagues at war's end to direct their efforts toward the problem of sophisticating the storage, processing and retrieval of information. In his now famous article entitled "As We May Think" he stated:

> "...He (man) has built a civilization so complex that he needs to mechanize his records more fully if he is to push his experiment to its logical conclusion and not merely become bogged down part way there by over taxing his limited memory. His excursions may be more enjoyable if he can reacquire the privilege of forgetting the manifold things he does not need to have immediately at hand, with some assurance that he can find them again if they prove important." (4)

* Parenthetical references placed superior to the line of text refer to the bibliography.

But the growth of scientific output has continued unabated such that in more recent years an ever increasing chorus of voices crossing all disciplines may be heard expressing alarm at the accretion rate of records in fields of science. Indeed many scholars have elaborated the theory of the exponential growth of scientific knowledge and literature. The following quotes illustrate the existing concern.

> "The world's scientific community is presently generating a flood of technical literature, and much of it is not getting into the hands of people who could use it." (5)

> "As the mass of information produced by scientists and engineers increases (at rates estimated to be exponential), the inadequacies of available methods of handling information are revealed: dissemination is delayed because publication media are backlogged: retrieval is delayed because the time needed to search for information is a function of the amount of information to be searched." (6)

Senator Hubert H. Humphrey in a televised introduction to a panel discussion presented in connection with the 1962 Convention of Special Libraries Association stated that the world is in a midst of a "Revolution in Information."

> "The ironic fact is that the sheer mass of information almost defeats our efforts to find what we are looking for. The result is that a vast amount of information is unfortunately, not really at our command. It may be known, but inaccessible; or it may be unknown or perhaps lost or forgotten." (7)

Francis Bello earlier expressed a similar sentiment and suggested the obvious means for wrestling with the problem.

> "Mankind is learning things so fast that its a problem how to store information so it can be found when needed.

Not finding it costs the U.S. over $1 billion a year.
Now machines are being called on for help." (8)

Currently there exists no quantitative means for accurately measuring the output of technical literature. However this does not preclude the possibility of obtaining some partial definition of it. It may be said that there are now somewhere between 50,000 and 100,000 technical journals being published in more than sixty languages. New journals keep appearing at the rate of at least two a day. This year's journals will carry between one million and two million significant technical articles with a yearly increase of five to eight per cent.(9),(10) And what is more astounding is the fact that the world's supply of recorded knowledge more than doubles every 15 years.(11) To this must be added an increase in content so vast it can not be measured.

In view of the foregoing a literature crisis might be defined as: an explosion or revolution producing at a geometrical or exponential rate piles, masses, mountains or floods of information to bogg down, inundate, bury or even drown poor humanity. Such a definition is exaggeratory only to the extent of its redundant terms, beyond this it is accurate. Even the famed mathematician and philosopher, Yehoshua Bar-Hillel, who rejects the urgency and the existence of a crisis in science, recognizes the possible crisis in the fields of patents, law and library acquisitions.(12) Suffice it to say that an information crisis does exist. Beyond the ominous declarations of competent scientists, the incontrovertible fact remains that millions of dollars are being spent annually by the National Science Foundation, the three military services, with particular emphasis by the U.S. Air Force, the Council of Library Resources, commercial organizations and

a handful of interested academicians in developing systems that will analyze, store, and, on demand, accurately retrieve what has been published.[13], [14]

B. Advent of Mechanized Information Retireval

The rapid escalation in recorded knowledge has had the following irreversible effects upon man as a user of information.

(A) Limited by his finite capacity for absorption and retention, man is forced to specialize.

(B) The scope of his specialty is shrinking as man finds it increasingly more difficult to keep informed and current.

(C) Man desires more specific and detailed responses to his information needs.

(D) Attendant to the foregoing is the matter of timeliness. Man wants to find the information he is searching for more rapidly.

Man is not alone, repositories of recorded knowledge are also being effected.

(A) Libraries sample and offer less material because of the enormity of recorded knowledge.

(B) The traditional library has given way to specialized libraries and specialized information centers in response to man's more detailed searches.

(C) Libraries and specialized information centers are applying modern machines to expedite the processing, searching and delivery of information.

In essence the inordinate size of recorded knowledge has precipitated a new discipline. Some call it "librarianship", others call it "documentation science" or "information science". Whatever the label, its reference is clear; the effective management of man's heritage of information.[15] It transcends traditional librarianship by featuring the skills combination of the librarian, the documentalist, the publisher, the writer, the editor, and very important - the scientist and engineer. That puts everyone into the game.[16] The interest of this multidisciplinary corps is in the handling of specialized knowledge. Its exponents seek to make information available - quickly, conveniently, accurately - to the man who seeks to add to knowledge or to draw upon it. The embodiment of this aspiration logically leads to an information storage and retrieval system. And for clarity's sake the definition of such a system seems appropriate.

"A storage and retrieval system in its simplest terms is an organized method for putting items away in a manner which permits or facilitates their recall or retrieval from storage. This definition, although essentially circular, is intended to establish that a storage and retrieval system must be considered as a single system and not as a storage system plus a retrieval system."[17] In other words, the method of storage determines to a considerable extent the possibilities of retrieval. Conversely, the requirements of retrieval establish the range of methods of storage. Continuing, "mechanized" information retrieval merely implies the utilization of machines (from the simple to the complex) to augment a storage and retrieval system.

Experience in mechanized information retrieval indicates that, in general, it must handle these types of material:

(a) large files or collections of documents;

(b) complex subject matter, usually containing many subjects of potential interest;

(c) scattered information, usually requiring selection from among many documents and subsequent correlation.(18)

Having explained that mechanized information came into being in order to ameliorate the conditions precipitated by the "Information Explosion" and having stated the types of material a mechanized information retrieval system handles, it is appropirate to discuss the component operations of such a system. Further, a discussion of the component operations of an information retrieval system continues the deductive manner (first stated in the introduction) in which this thesis is being developed. Parenthetically this "modus operandi" - proceeding from a general background of information retrieval to the specifics of machining indexing - was chosen on the assumption that a complete understanding of the evaluation of machine indexing is contingent upon the reader's having a clear idea how machine indexing, per se, fits into the total information retrieval picture. With this in mind, the component operations or unit operations of an information retrieval system follow in logical sequence.

C. Unit Operations

Any information retrieval system, whether based on traditional library methods or on the most modern machines, involves a series of steps which Allen Kent, Director of the Knowledge Availability Systems Center at the University of Pittsburgh, terms "unit operations." They are: acquisition, analysis, terminology control, recording of results of analysis, storage of source documents, question analysis, searching, and delivery of search results. Except for a description of each, only the second unit operation - analysis - will be discussed at any length.

It is worth noting that these unit operations can not be performed to precise specifications, that is, it is difficult to delineate precisely where one begins and the other ends. Additionally, some may be performed simultaneously or at different times. The following columnar list gives Mr. Kent's unique and original description of each.(19)

Unit Operation	Functions Performed
Input	
1. Acquisition	Locating, selecting, ordering and receiving of source documents for a collection.
2. Analysis	Perusual of source documents and selection of points of view (or analytics) that are considered to be of sufficient probable importance to warrant the effort of rendering them searchable in the system.
a. Abstracting	Concentrating the essential qualities of a larger thing - a summary of a publication accompanied by an adequate bibliographic description, to enable the publication to be traced.

	b. Indexing	Selection of words or ideas from a graphic record on the basis of well-defined rules, in order to facilitate the identification or selection of desired records after they have been stored.
	c. Classifying	Arranging or placing in a class on the basis of similarities or differences.
	d. Extracting	Selecting for quotation portions or source material.
3.	Terminology Control	Establishing arbitrary relationships among analytics, e.g., based on similarities among analytics as revealed in dictionary definitions.
4.	Recording of Results of Analysis on Searchable Medium	Use of card, tape, film or other medium on which the analytics are transcribed.
5.	Storage of Source Documents	Physical placement of record in some location, either in original form, or transcribed or copied onto a new medium.

Output

1.	Question Analysis and Development of Search Strategy	Expression of question or problems, selection of analytics in terms of a particular search mechanism, and arrangement into a configuration that represents a probable link between the question as expressed and the records on file as analyzed.
2.	Conducting of Search	Manipulation or operation of the search mechanism in order to identify records in the file.
3.	Delivery of Results of Search	Physical removal or copying of record from file in order to provide it in response to question.

As may be readily inferred from the foregoing list, the term "input" implies the processing of documents into the system by system

operator personnel. Contrariwise, the term output implies the retrieval of data from the system by either system personnel or the user. Also, for simplicity's sake Mr. Kent limits the results of analysis to abstracts, extracts, classifications and indexes. It is recognized that this is not an exhaustive grouping. Results of analysis among other things includes annotations, first paragraphs, last paragraphs, tables of contents, etc.

D. Analysis

Analysis is the most time-consuming, laborious, ill-defined, complex, and undoubtedly the most important input unit operation. Its complexity stems from the fact that it is basically predictive. Naturally, because the analyst - digesting, reducing and making readily searchable the masses of documents or records being put into a system - is essentially attempting to predict the desires of a searcher who is separated from him in time and space. In effect the analyst is a middleman trying to serve two masters: the author by accurately representing his document, and the searcher or user by answering his information needs. It is axiomatic that no analyst can predict every possible point of view or use that could be demanded of any document.(20)

Analysis may be formally defined as the detailed examination of anything complex in order to understand its nature or determine its essential features. The specific purposes of this unit operation are:

(a) to provide a substitute for the original source material - abstract, extract or annotation;

(b) to permit determination as to whether it is useful to obtain and read the source material - abstract, extract or annotation;

(c) to permit identification of source materials that are probably of interest in connection with one or another quest for information - index entries or classification subject headings. (21)

These purposes establish the amount of detail, or depth of analysis as well as the form in which the result is provided, i.e., abstract, index, etc. The results of the analysis function may be represented graphically on a continuum which depicts the degree of processing to which the original document is processed. See Figure 1.

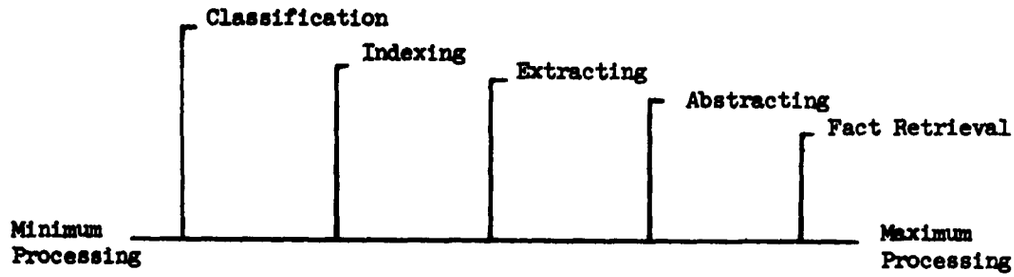

Figure 1: Degree of Document Processing

The four processes which comprise the analysis function are similar in certain respects. First, each of the processes, namely, abstracting, extracting, indexing, and classifying, could be performed independently. Second, all involve the following preliminary steps:

(a) reading and understanding the document or record being processed;

(b) deciding what aspects of subject content are important;

(c) selection of terminology or other symbolisms to designate the important aspects of subject content.[22]

As shown in Figure 2, these three basic preliminary operations are followed by different steps, in particular the composing of sentences in writing literary style abstracts, the copying of desired sentences from the source document for extracts, the establishment of index entries in the case of indexes and the assignment of class designations with classification systems.

Third, each process results in loss of information through the elimination of certain individual facts and the corresponding reduction in amount of recorded detail. Depending upon policy, the relative loss of information for each of these four types of output may vary within wide limits. For example, if current policy emphasizes research and development, scientific information will undoubtedly be retained in great detail while other information or facts may be arbitrarily lost. As a general rule, the information loss is minimal with literary style abstracts, particularly when these are written to be informative in character. Next in loss is extracts which lack continuity from sentence to sentence. The greatest loss in information occurs in assigning class designations which, as a rule, do little more than indicate that the subject contents of a given document pertain to one or more generic classification subdivisions. The totality of index entries pertaining to the contents of a document or graphic record usually is more informative than a classification heading. Additionally, although indexing will be discussed in more detail subsequently, it is worth noting

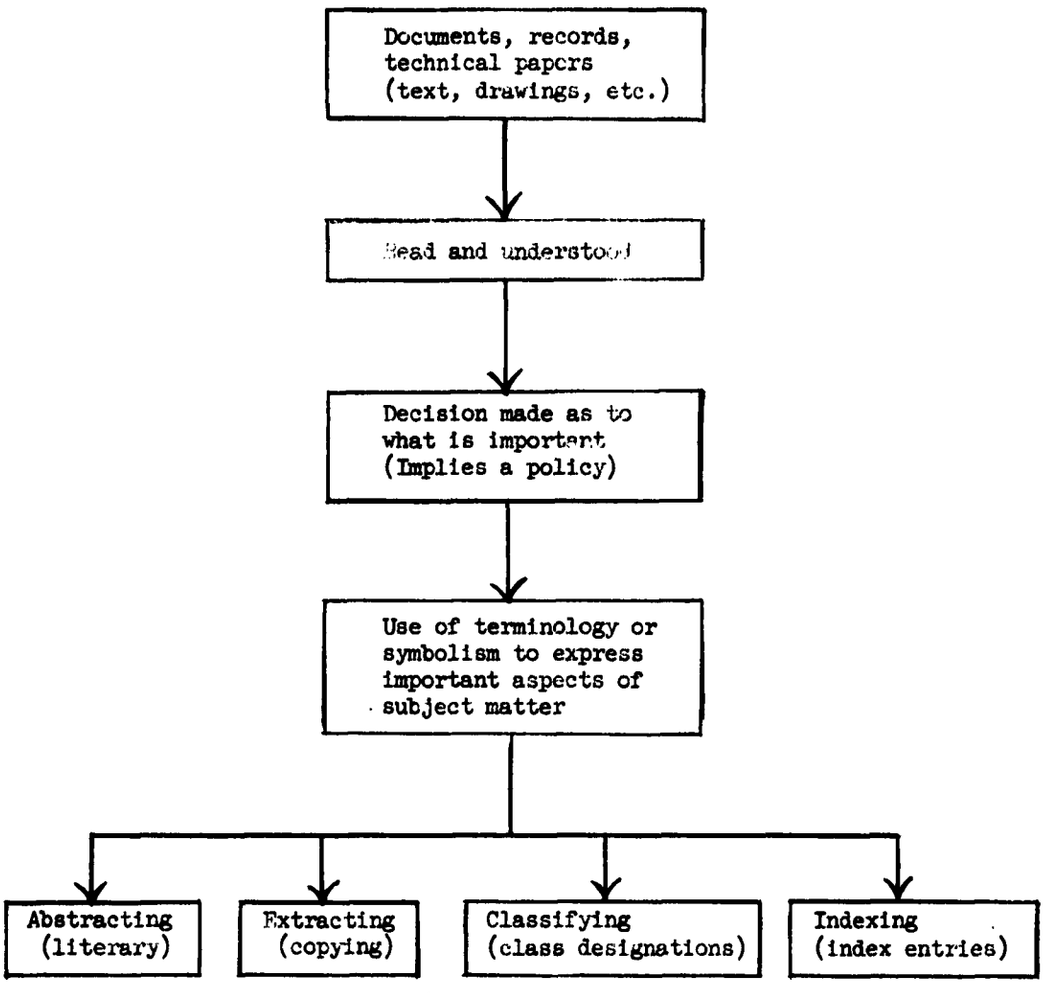

Figure 2: Preliminary Steps Common to Generating Abstracts, Extracts, Classifications and Indexes

now that taken separately each individual index entry, as encountered in alphabetized or similarly arranged lists, usually pertains to a single narrow feature of the subject contents of the original document. (23)

A detailed discussion of the analysis function is beyond the scope of this thesis. The preceding remarks concerning analysis are intended to provide a bridge between the unit operations and indexing.

E. Indexing

The importance of indexing is succinctly expressed by authoritative Calvin Mooers in the following comment:

> "The indexing language of an information retrieval system is the intellectual mechanism that makes the system operate. Next to the actual information stored in the collection, it is probably the most important part of the system. The indexing language is the means of mediating between the minds of the customers and the information stored in the collection. It is the bridge, the connection between the users and the information." (24)

Moreover, Allen Kent confirms the bridge idea and expresses the myriad nature of indexing methodology. Here is Mr. Kent on the subject:

> "If analysis may be thought of as the cry to open the gates to the flood of human imagination, then indexing may be considered the force that burst the dam and turned the stream of information handling methods into an unconstrained torrent. It is almost as though everyone concerned with specialized information activities has invented an indexing method of his own, and there seems to be more enthusiasm connected with this unit operation fragment than with any other." (25)

This "bridge" - indexing - may be defined as the selection of a set of terms or descriptors from an available vocabulary to describe an

item. Putting it in other words, the process of indexing involves the selection of words or ideas from a graphic record on the basis of well-defined rules; the purpose of indexing is to facilitate the identification or selection of desired documents after they have been sorted and stored.(26)

A number of factors must be taken into consideration in determining index requirements for a particular collection of documents. These include the value of information contained in the collection, its size and use, the required speed and completeness of retrieval, and last but not least, the type or types of questions asked of the collection.(27) The type of index is directly related to types of search questions. The following table illustrates how one research company matches index requirements with types of search questions.(28)

Types of Requests	Types of Indexes
Report by code	Collection arranged by code - no index required
Report by author	Author index
Report by title	Index to titles, shallow subject index, permuted title index.
General background information	Shallow subject index
Information in document on:	
Specific subject	Alphabetic subject index
Generic subject	Classified index
Coordinate subject, i.e. effect of part of chemical such as functional group on its properties	Coordinate index

Essentially, the general operations in indexing and searching may be reduced to this: A document is read for indexable information; concepts are selected that represent important aspects of this document, aspects that will provide future handles for getting at the document. This indexable information is then translated into standard index language. In searching the index the operation is reversed. The question is first translated into the language of the index. Thereupon the desired document is chosen.(29) This description is elementary, almost infantile, but simple as the operation may seem it is not without serious complications. These complications arise because indexing is predictive and represents a loss in information as stated earlier.(30) Moreover, according to Frederick Jonker it is diffuseness, not just volume, which compounds the indexing and, for that matter, the entire information problem. Dr. Jonker asserts:

> "Diffuseness of information implies that items of information may be of interest in a great many problems, uses, and fields of pure and applied science. It implies that these items should be indexed from each viewpoint of potential importance. The diffuseness of an item of information therefore is measured by the number of potential indexing viewpoints or criteria."
>
> "By far the greatest proportion of our present store of knowledge which we need to consult constantly and rapidly is of a highly diffuse nature. This high degree of diffuseness is not something accidental. It is inherent in the very nature of our technological civilization, in the fact that every achievement or finding in any particular field may be of enormous potential interest in almost any other field. It is this crossfertilization which is responsible for the rapid acceleration of progress, which, measured by the time scale of history, almost assumes the proportions of an explosion. Here indexing theory touches the mechanism of progress." (31)

Studies devoted to evaluating the capabilities and limitations of subject indexes have led to the conclusion that they are inadequate in the form in which they have been previously produced to respond to many information requirements, especially those whose scope may specify one or more generic concepts. These inadequacies in subject indexes, mounting concern at the time and cost of index preparation, plus an urgent need to increase the level of efficiency in scientific research and development, have provided the impetus for applying and developing various automatic and semiautomatic devices to accomplish the identification of documents, reports and other technical literature that are of keen interest to a given R and D problem.(32) The net result is that in the past 20 years of increasing information retrieval research many breakthroughs have been achieved, one of which is the successful application of machines to the indexing syndrome.

F. Machine Indexing

1. General

Before discussing the various approaches to automatic or machine indexing a few general comments seem appropriate. First, one of the primary objectives of research in machine indexing is minimizing the human physical and intellectual effort at the "input" end, that is, in processing documents or records into the system. The aim is to derive the appropriate index entries directly from the unedited text of a document. The intermediate human efforts of creating or designating index entries to stand

for a document in storage and coding this data prior to feeding it into a computer are eliminated.

Second, automatic indexing should not be confused, as it often is in the literature, with mechanical storage or with mechanical searching systems. The latter merely store away and search for index entries that were created and coded by human effort. Understand, of course, that a machine index may be used in conjunction with mechanical storage and retrieval systems.

And third, the automatic processing of information requires that the full text of a document be available in some machine-readable form such as punched cards or paper or magnetic tape. Also, the earlier in the production process the text is available in machinable form, the greater the saving.(33) In the case of the permuted index, which will be discussed in great detail subsequently, this aspect is not significant because only the bibliographic data pertaining to a document need be in machine readable form.

2. Approaches to Machine Indexing

There are three basic techniques for machine indexing. They are: the statistical, the linguistic (syntatic) and the semantic.

The statistical approach utilizes the frequency of occurrence of words and their relative distance from one another within the document as the rationale for determining which words from the text are suitable index entries.

The linguistic approach depends upon a modern linguistic analysis of the language structure such as grammer, word order and other distinctive

forms a word may assume. It is based on the assumption that "the ability of the machine adequately to determine information relevance depends strongly on its ability to recognize and manipulate the syntactic structure of the text."[34],[35],[36]

The semantic approach embraces the nature of meaning of words. Strictly speaking, words have "meaning" only as they are used in particular statements. They can be studied individually, but as they are recorded in a dictionary, which offers their linguistic data, they have only typical or possible meaning. Which sense was intended is usually clear from the sentence in which it is used - that is, from the "context".[37] "The semantic approach, according to Climenson and his colleagues, evolved from the traditional interest in semantic classification, descriptive terms, cross-indexing of related subject fields, etc."[38],[39]

In practice, most approaches are a combination of the three. It may help to think of these techniques as a continuum of structural information, see Figure 3, ranging from the individual word as a complete and highly structured unit on the one hand to pure meaning on the other hand.[40]

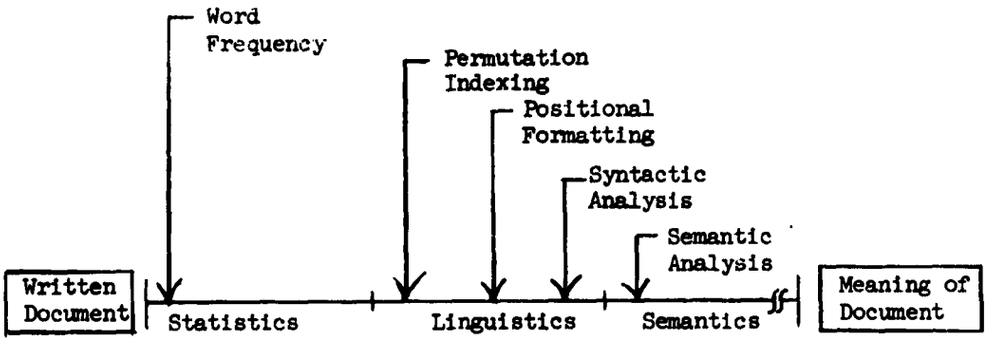

Figure 3: Degree of Format Structure

To date, these approaches have achieved varying degrees of success in producing machine-made indexes from textual material. More sophisticated techniques for automatic selection of indexable matter from unedited text and automatic processing into suitable index entries are currently being developed.

Still there is another approach to machine indexing, one which obviates the complexities of manipulating unedited text since it deals exclusively with the titles of documents. There are, in fact, several methods based on the use of the title only. The most widely used of these is the "Keyword-in-Context" or KWIC index. It is this mode of indexing which will comprise the body of this thesis.

Before discussing KWIC indexing in detail, however, a glance at Figure 4 will graphically reveal how KWIC indexing fits into an information retrieval system and, no less important, the deductive development of this thesis.

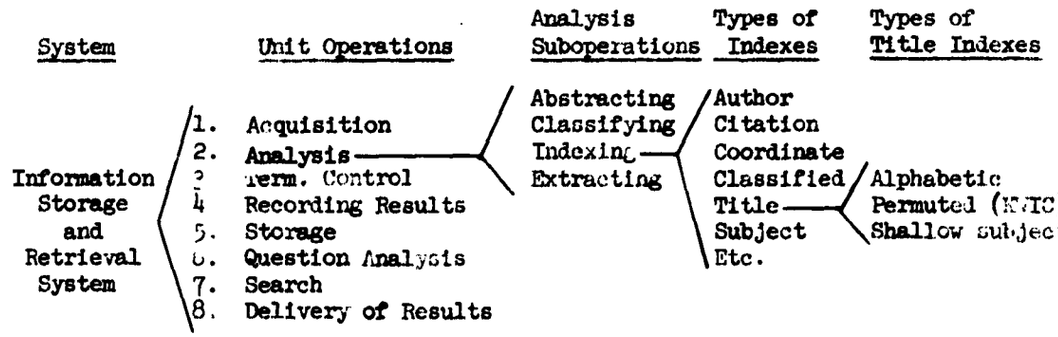

Figure 4: Development of Thesis: From the General to the Specific

II. KEYWORD-IN-CONTEXT (KWIC) INDEX

KWIC is a machine-generated printed index of documents which uses as index entries solely the keywords in the document titles. A KWIC index is frequently referred to as a permuted title index, since the words in the title to a document are rotated or permuted, one at a time. Figure 5 illustrates how the title "Statistical Analysis in Advanced Information Retrieval", might appear in a KWIC or permuted title index.

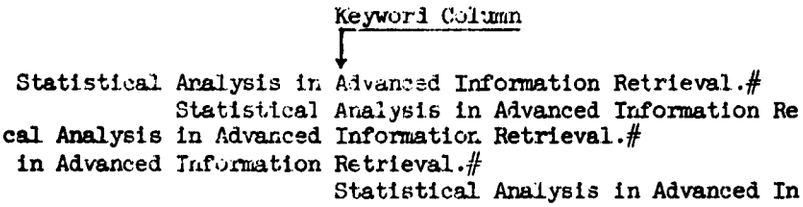

Figure 5: KWIC Index Example Using a Single Title

Note that all words in the title with the exception of "in" have been rotated under the keyword column and that each indexing word or keyword appears in alphabetical order.

Normally this title would appear in a KWIC index five times, once for each keyword. On the subject of keywords, H. P. Luhn, the originator of KWIC indexing has this to say:

> "Keywords need only be defined as those which characterize a subject more than others. To derive them, simple rules have to be established for differentiating between what is significant and what is non-significant. Since significance is difficult to predict, it is more practical to isolate it by rejecting all obviously non-significant or "common" words, with the risk of admitting certain words of

> questionable status. Such words may subsequently be eliminated or tolerated as so much "noise". A list of non-significant words (called a stoplist) would include articles, conjunctions, prepositions, auxiliary verbs, certain adjectives and words such as "report", "analysis", "theory", and the like. It would become the task of an editor to extend this list as required." (41)

A typical stoplist might include, but certainly not be restricted to, the following:

a	been	if	our	these
ago	but	in	put	those
all	by	into	see	thru
also	do	it	she	to
an	for	me	so	too
and	from	my	some	upon
any	he	of	than	we
as	her	off	the	with
at	him	on	then	yet
be	his	or	there	you (42)

The phrase "in-context" suggests that after the keywords are alphabetically ordered, they appear at one location in relation to the other words in the title. Further, the resulting index listing contains the words which surround the keyword, so that the user can read the keyword in its context.

Usually, a KWIC index consists of three parts or sections: Keyword Index, Bibliography and Author Index. Figures 7, 8 and 9 are examples of each.(43) In Figure 7 note that the keywords have been arranged alphabetically to the right of the blank column. A total of 60 characters is printed (this may vary with individual preference), 24 to the left of the keyword and 35 to the right of it. Because the space allotted to titles in a KWIC index proper is fixed, many entries will show only part of a

title. A technique called "wrap around" (also called recirculation or snap-back) is employed to make maximum use of available space. For comparison, observe that Figure 5 does not employ wrap-around, but Figure 6 does. In Figure 5 considerable empty space may appear either to the right or left of an entry - particularly if the keyword is the first or last word in the title. This space may later be filled with more of the context of the keyword. Just how many other words can be shown depends upon the length of the particular keyword and the total number of spaces allotted to the title. (Sixty spaces are used for the titles shown in Figure 7; also, note the use of wrap-around.)

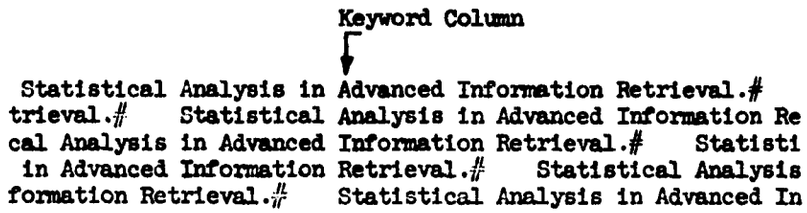

Figure 6: KWIC Index Using "Wrap-Around"

To the right of each entry in the KWIC index proper appears a reference code. This directs the user to the proper bibliographical entry, where he will find complete information regarding the title, author and source (see Figure 7). Thus the usual KWIC index requires a double look-up to actually find or order a document - once in the KWIC (or author) index and once in the bibliographic index.

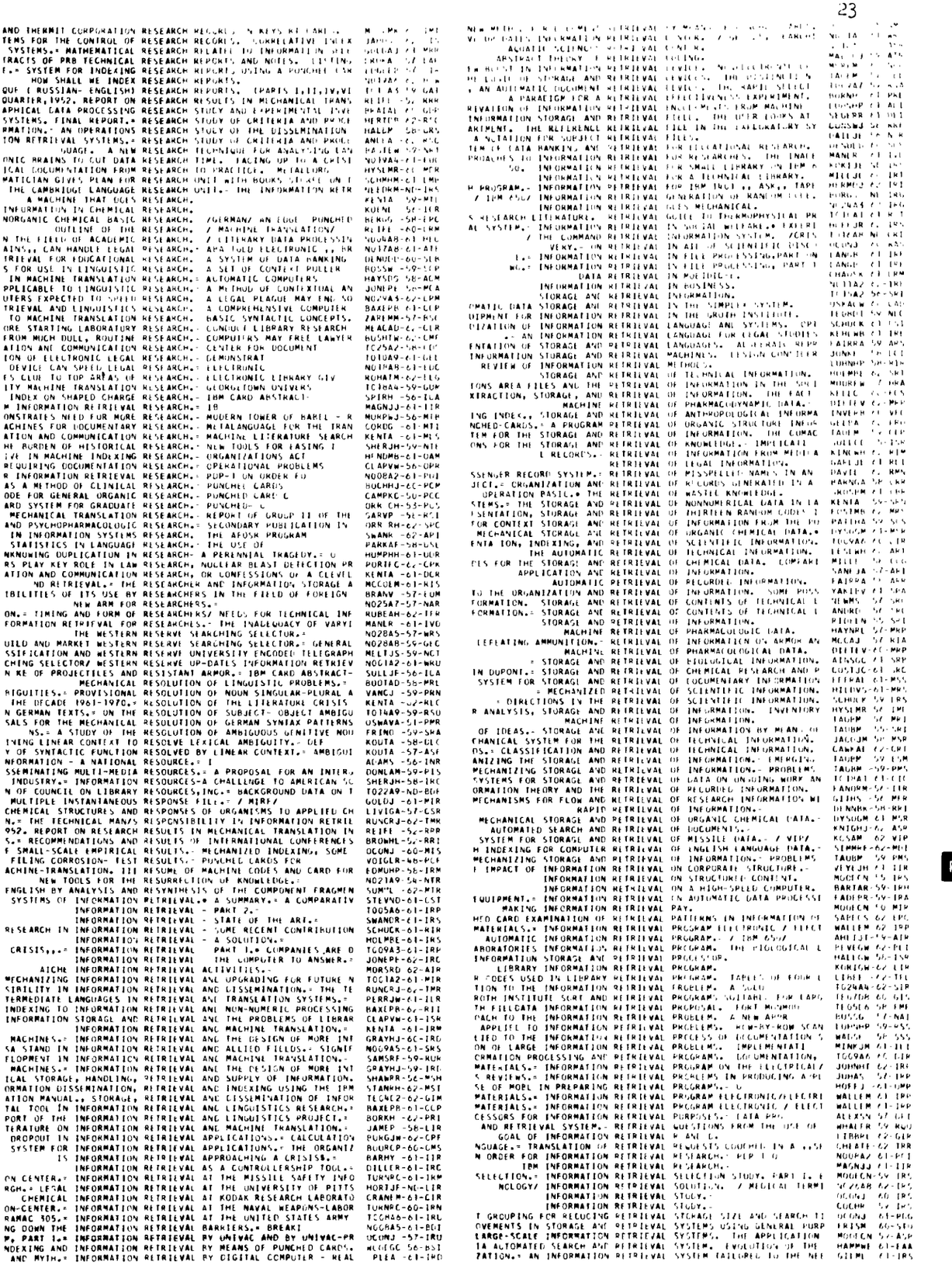

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Figure 7: Typical Page From a KWIC Index Proper

F PROVIDING INFORMATI N RETRIEVAL / ITEM, A CLA... / REED, ANGELA ...
MECHANIZED INFORMATION RETRIEVAL SYSTEM FOR THE MEDLARS AC FONDIL ... / ...
ION FOR AN INFORMATION RETRIEVAL SYSTEM, DYNAMIC STORAGE A SAMUELSON ...
SELECTION AND FACSIMILE RETRIEVAL SYSTEM, MECHANIZED INF R BAGGETT ...
E NUMERICAL INFORMATION RETRIEVAL SYSTEM, A TELEKINESIA ... / REED, ...
COORDINATE INFORMATION RETRIEVAL SYSTEM, THE CAN OF WO ... / ...
THEORY AND STORAGE AND RETRIEVAL SYSTEMS, COMMUNICATION ... / ...
INFORMATION STORAGE AND RETRIEVAL SYSTEMS, THE RELATIONSHIP HERNS, ...
INFORMATION STORAGE AND RETRIEVAL SYSTEM, THE MACHINE REPRT MARRON ...
ING RECORDS STORAGE AND RETRIEVAL SYSTEM, THE MATE... / ANGELL ...
NCTIONS FOR INFORMATION RETRIEVAL SYSTEM, THE EFFICIENCY OF ... / ZERO, ...
UCTURES AND STORAGE AND RETRIEVAL SYSTEMS, MEANING LENGTH ... / ...
SCIENTIFIC INFORMATION RETRIEVAL SYSTEM FOR MACHINE PRINT MOOERS, ...
BASIS FOR INFORMATION RETRIEVAL SYSTEM, PROGRAMMED INTER DOYLE, ...
LANGUAGE ORIENTED RETRIEVAL SYSTEMS, ... / ...
TERMED BY A STORAGE AND RETRIEVAL SYSTEM, THE RELATION OF T KLINPH, ...
SAL, ASSIA/S RETRIEVAL SYSTEM, AN INTERIM APPRAI TAUBE, ...
MECHANICAL INFORMATION RETRIEVAL SYSTEM, MANUAL RAREWA, ...
OQERS// LAW OR, WHY SOME RETRIEVAL SYSTEMS ARE USED AND OTHER KOLEJ, ...
ECHANICS OF STORAGE AND RETRIEVAL SYSTEMS, (INTRO). E OF A MOOERS, ...
DEVELOPING INFORMATION RETRIEVAL SYSTEMS OF LARGE ELECTRONI OPLER, ...
CUMENTS FOR INFORMATION RETRIEVAL SYSTEM, AN APPROACH TO DOWNHP, ...
TRUCTURE OF INFORMATION RETRIEVAL SYSTEMS, THE VIERKE, ...
SCIENTIFIC INFORMATION RETRIEVAL SYSTEMS, RESEARCH IN THEY ANETA, ...
OF LINDEX/S INDEXING AND RETRIEVAL SYSTEM, RETRIEVAL COMBIN WHALER, ...
TH LINDEX/S INDEXING AND RETRIEVAL SYSTEM, OPERATIONAL EXPER WHALER, ...
/AUTOCODING INFORMATION STORAGE AND RETRIEVAL SYSTEMS, A CASE HISTORY OF BRENDW, ...
INFORMATION STORAGE AND RETRIEVAL SYSTEM FOR A GUIDED MISSILE HAMAHA, ...
CTIVE DISSEMINATION AND RETRIEVAL SYSTEMS, DESIGN DEVELOPME HENSON, ...
EW ON RETRIEVAL SYSTEM THEORY, /BOOK REVI WAKHIA, ...
TY DOCUMENT STORAGE AND RETRIEVAL SYSTEMS, / WALNUT, RANDOM PORTER, ...
ON RETRIEVAL SYSTEM THEORY, VIERKE, ...
F PER CARGE INFORMATION RETRIEVAL SYSTEMS, A SCREENING METH MOORE, ...
WITHIN TWO INFORMATION RETRIEVAL SYSTEMS, A COMPARISON OF SCHULER, ...
MECHANIZED INFORMATION RETRIEVAL SYSTEMS, THE HISTORICAL D RUDRUP, ...
THE IBM 650 INFORMATION RETRIEVAL SYSTEM, AMLIE, ...
MULTIPLE CARD ABSTRACT RETRIEVAL SYSTEM, A WEIGH, ...
FICIENCY OF STORAGE AND RETRIEVAL SYSTEMS, COST AS THE MEAS TAUBM, ...
REMENT, AN INFORMATION RETRIEVAL SYSTEM FOR A SMALL RESEARC AXELER, ...
SCIENTIFIC INFORMATION RETRIEVAL SYSTEMS, FINAL REPORT, HEISER, ...
ACTERS IN THE DESIGN OF RETRIEVAL SYSTEMS, SOME FACET CLERI FAIRRA, ...
REPORT ON RETRIEVAL SYSTEMS, VESSJH, ...
DESK SIZED INFORMATION RETRIEVAL SYSTEM, NUTMAP, ...
EVIEW, NONCONVENTIONAL SYSTEMS IN ECONOMIZATI N, KESTA, ...
TY DOCUMENT STORAGE AND RETRIEVAL SYSTEM, FACT SHEET ON WAT SOLTAY, ...
REPORT ON RETRIEVAL SYSTEMS II, VESSJH, ...
MICROFILM STORAGE AND RETRIEVAL SYSTEM, NOZZAS, ...
D CODING IN INFORMATION RETRIEVAL SYSTEMS, CHOICE AS MOOERS, ...
INFORMATION STORAGE AND RETRIEVAL SYSTEMS, REQUIREMENTS FOR EDUCREP, ...
DOCUMENT IMAGE RETRIEVAL SYSTEM PROVIDED BY FCA, NOZZAB, ...
FORMANCE OF INFORMATION RETRIEVAL SYSTEMS, THE INTENSIVE SA MOOERS, ...
ANDOM ORDER, RETRIEVAL SYSTEM STORES RECORDS IN A NOZ3AT, ...
N EFFICIENT INFORMATION RETRIEVAL SYSTEM, SOME CHARACTERIST SCHUCK, ...
DGE NOTCHED INFORMATION RETRIEVAL SYSTEMS, INFORMATION RETRI HOFFER, ...
M OBTAINING INFORMATION RETRIEVAL SYSTEMS, MACHINE LITERATU KENTA, ...
BUILDING AN INFORMATION RETRIEVAL SYSTEM, KLEIN, ...
AUTOMATION OF DOCUMENT RETRIEVAL SYSTEMS, RECENT DEVELOPME KLECZ, ...
INFORMATION FILING AND RETRIEVAL SYSTEM FOR THE ENGINEERING HAMNJA, ...
INFORMATION STORAGE AND RETRIEVAL SYSTEMS, MAGNACARD, MAGNA LAURPE, ...
OF A SIMPLE INFORMATION RETRIEVAL SYSTEM IN THE SMOKE INSTIT VANEV, ...
RANG PUNCHED CARD DATA RETRIEVAL SYSTEM, A REMINGTON MATHOJ, ...
AN-GSG-387 INFORMATION RETRIEVAL SYSTEM FOR U.S. AIR FORCE, NOLMAN, ...
INFORMATION STORAGE AND RETRIEVAL SYSTEM PAYS OFF-- MECHANIZ TOTAN, ...
TY DOCUMENT STORAGE AND RETRIEVAL SYSTEMS, THE WALNUT SYSTEM BRAILE, ...
A MANUAL INFORMATION RETRIEVAL SYSTEM, CONFSPC, ...
ORMULATIVE INDEXING AND RETRIEVAL SYSTEM FOR THE SCREENING O ELIAAM, ...
NUAL FOR A PUNCHED CARD INFORMATION RETRIEVAL SYSTEM FOR TRANSL PRUMU, ...
TRUCTION OF INFORMATION RETRIEVAL SYSTEMS, PROBLEMS IN THE WEIRPC, ...
LINATION IN INFORMATION RETRIEVAL SYSTEMS, CONCEPT COOR NOZZAZ, ...
FIRST STEPS TOWARD RETRIEVAL SYSTEMS, FAIRRA, ...
ME COMMENTS ON THE IRIA RETRIEVAL SYSTEMS, SU MOLEN, ...
FICIENCY OF INFORMATION RETRIEVAL SYSTEMS, AN INVESTIGATION CLEVCW, ...
UNIT, THE IMPLEMENTATION OF THE CAMMEGIE LA NEIERM, ...
- IBM 1401 INFORMATION RETRIEVAL SYSTEM, INVERTED CARD FIL NEWKM, ...
A PHOTO MAGNETIC RETRIEVAL SYSTEM, SUSTEJ, ...
AN INFORMATION RETRIEVAL SYSTEMS, PWR
ION MANUAL, INFORMATION RETRIEVAL SYSTEMS CONFERENCE, SEPTEM NOSAT, ...
MECHANIZED INFORMATION RETRIEVAL SYSTEM FOR DOUGLAS AIRCRAF TECHSM, ...
E PRACTICAL INFORMATION RETRIEVAL SYSTEM CRITERIA, PROPOSAL FORSON, ...
SNOOP- AN INFORMATION RETRIEVAL TECHNIQUE FOR THE IBM 7607 CLEVCW, ...
T/S KNOWN.- INFORMATION RETRIEVAL TECHNIQUES TO MAKE THE MAS HERBE, ...
ICABILITY.- INFORMATION RETRIEVAL TECHNIQUE DEVISED BY SYSTE NCC2A5, ...
MONSTRATING STORAGE AND RETRIEVAL TECHNIQUES, IN STRUDR, ...
TACHMENT). INFORMATION RETRIEVAL THEORY FOR PERFORM SCANNIN COMSMP, ...
IONS FOR A STORAGE AND RETRIEVAL THEORY, MATHEMATICAL FOUN KREIA, ...
LICATION OF STORAGE AND RETRIEVAL THEORY, THE MINIGARD SYST TOZ7AT, ...
SPONSENCE.- CONTROL AND RETRIEVAL THEORY, MICROFILM AND PUNC DEVITT, ...
INFORMATION STORAGE AND RETRIEVAL THESES STUDIES, NOZ9AV, ...
TO CARDS AND MECHANICAL RETRIEVAL TO LEGAL RESEARCH AND INF MAEKER, ...
PA- INFORMATION RETRIEVAL TWO NEWBLE MILES N IN TOP NOISAZ, ...
ASTM PUYS TERMATREX RETRIEVAL SYST, NOIP4, ...
OR, MACHINE RETRIEVAL TYING THE ASSOCIATION FACT STIEHE, ...
INFORMATION STORAGE AND RETRIEVAL TYING A LARGE SCALE RANDOM NOLAJJ, ...
INFORMATION STORAGE AND RETRIEVAL USING RAMAC, NOLAJJ, ...
R MEGA ITEM INFORMATION RETRIEVAL USING SMALL SET MACHINES TECHPZ, ...
ING.- INFORMATION RETRIEVAL VIEWED AS TEMPORAL SIGNALS MOOECN, ...
CONCEPT OF INFORMATION RETRIEVAL WHICH PAGE THE WAY TO AUT NUCHAW, ...
MINOLOGY IN INFORMATION RETRIEVAL, A SUMMARY OF RECENT WORK, MERRJH, ...
NTATION AND INFORMATION RETRIEVAL, A SELECTED BIBLIOGRAPHY, TECZ5, ...
INFORMATION STORAGE AND RETRIEVAL, I- ON THE USE OF SDEEL IN PUCKRC, ...
CONCEPTS OF INFORMATION RETRIEVAL, PART I, BASIC, TORANJ, ...
INFORMATION STORAGE AND RETRIEVAL, PART I, DOCS, CASS, AND E GLEMAE, ...
ENGINEERS.- INFORMATION RETRIEVAL, TECHNICAL REPORTS CENTER/ NOTIAS, ...
OF MACHINES, IN TOCUMENT RETRIEVAL,- DEFINITIONS AND SCOPE,- BOHNEM, ...
INFORMATION RETRIEVAL,- FINDING ,- LISTS, FACTS, THOMJP, ...
SYSTEMS OF INFORMATION RETRIEVAL,- A SUMMARY, A COMPARATIV STEVNE, ...
INFORMATION RETRIEVAL,- A PRAGMATIC APPROACH, ARNODW, ...
UISTICS AND INFORMATION RETRIEVAL,- TOWARD A SOLUTION OF THE NEWMJM, ...
E DESK.- INFORMATION RETRIEVAL,- A VIEW FROM THE REFERENC FRANM, ...
G SYSTEMS.- INFORMATION RETRIEVAL,- GENERAL PURPOSE DATA PRO FAIDER, ...
INFORMATION RETRIEVAL,- PUNCHED CARD EQUIPMENT,- FAIERR, ...
EQUIPMENT, INFORMATION RETRIEVAL,- PUNCHED CARD TECHNIQUES, FAIDER, ...
TY YEARS IN INFORMATION RETRIEVAL,- SOME GOALS AND PREDICTIO MOOECN, ...
NTATION AND INFORMATION RETRIEVAL,- AN INTRODUCTION TO BASIC PERRJW, ...
CTIVITIES, INFORMATION RETRIEVAL,- EMPLOYMENT OPENINGS FOR INE HEYDE, ...
YSTACK, INFORMATION RETRIEVAL,- FINDING A NEEDLE IN A HA NOJ9A2, ...
INFORMATION STORAGE AND RETRIEVAL,- THEORY, SYSTEMS AND DEVI TAUBM, ...
F INFORMATION RETRIEVAL,- IT FITS MANY SITUATIONS, PLESN, ...
ODUCTION TO INFORMATION RETRIEVAL,- GENERAL INFORMATION MANU TOZ9AT, ...
OMPUTERS TO INFORMATION RETRIEVAL,- APPLICATION OF HIGH-SPEE ANEREO, ...
YMBOLS IN INFORMATIONAL RETRIEVAL, SOME MATHEMATICAL FUNDAM MOOECN, ...
TOWARDS INFORMATION RETRIEVAL, FAIRRA, ...
F CODES FOR INFORMATION RETRIEVAL, PROBLEMS INVOLVED IN DEGRE, ...
MATIONS FOR INFORMATION RETRIEVAL, LINGUISTIC TRANSFOR HANNJ, ...
ESSENTIALS FOR DOCUMENT RETRIEVAL, FAIRRA, ...

INFORMATION RETRIEVAL, / VERAC SYSTEMS/ NCISAA, ...
ICATION FOR INFORMATION RETRIEVAL, PREFACINGS TO THE INTER DOVA, ...
TRANSLATION AND LIBRARY RETRIEVAL, THE ANALYSIS BETWEEN MECH MASIM, ...
EQPMENTS IN INFORMATION RETRIEVAL, /ATOMICING AND LEVE MOLEN, ...
NALYSIS AND INFORMATION RETRIEVAL, ECONOMICA GARELJE, ...
NDEXING AND INFORMATION RETRIEVAL, ON RELEVANCE, PROBABILIST MANOME, ...
OF LANGUAGE SYMBOLS IN RETRIEVAL, A MATHEMATICAL THEORY MOOLEN, ...
SCANNING INFORMATION RETRIEVAL, SPECIFICATIONS GOUFJD, ...
WORK MODELS FOR MACHINE RETRIEVAL,- A CLASS OF SEA WONGJ, ...
PLANNING FOR DATA RETRIEVAL, VEYIJH, ...
FORMATION STORAGE AND RETRIEVAL, A CASE HISTORY IN AUTOMA VALLTA, ...
NEW APPROACHES FOR DATA RETRIEVAL, SHOMS NOVAAV, ...
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CODING FOR INFORMATION RETRIEVAL,- PRIME NUMBER COCKAN, ...
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FACTORS IN INFORMATION RETRIEVAL, TIME, COST AND VALUE MUELMW, ...
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MICS,- AN EXPERIMENT IN INFORMATION RETRIEVAL, CLASSIFICATION WITH A PE WRIGRE, ...
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OMATIC FILE STORAGE AND RETRIEVAL, AUT NUTCAT, ...
IZATION FOR INFORMATION RETRIEVAL, REFERENCE MANUAL INDEX O TCF2A6, ...
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ONSTRATE TECHNIQUES FOR RETRIEVAL,- A COMPUTER WILL BE USED NOISA5, ...
INFORMATION RETRIEVAL, VEYIJH, ...
INFORMATION RETRIEVAL, NOTOA4, ...
IBM AND INFORMATION RETRIEVAL, NOUHAV, ...
EADYING INFORMATION FOR RETRIEVAL,- MAZE HUNTS ORGANIC PEST NOISAH, ...
CLOSURES FOR MECHANIZED RETRIEVAL, ORGANIZATION OF CHEMICAL EANHAE, ...
ASPECTS OF INFORMATION RETRIEVAL, SOME LINGUISTIC GAKVPE, ...
F UNIVERSAL INFORMATION RETRIEVAL,- N BELZJ, ...
SYSTEM FOR INFORMATION RETRIEVAL,- THE ATOM GENERP, ...
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NEW DEPARTURE IN DATA RETRIEVAL, PORTEC, ...
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N FACTOR IN INFORMATION RETRIEVAL, THE ASSOCIATIO STIEHE, ...
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TOMATION OF INFORMATION RETRIEVAL, AU PERRJW, ...
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DATA RETRIEVAL, WILECM, ...
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INFORMATION RETRIEVAL, NOZ0A1, ...
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N FACTOR IN INFORMATION RETRIEVAL,- PROGRESS IN THE USE OF T STIEHE, ...
NTATION AND INFORMATION RETRIEVAL,- THE IDENTIFICATION OF CO LOCUMS PERRJW, ...
N AUTOMATIC INFORMATION RETRIEVAL, SALTG, ...
INFORMATION STORAGE AND RETRIEVAL, SALIG, ...
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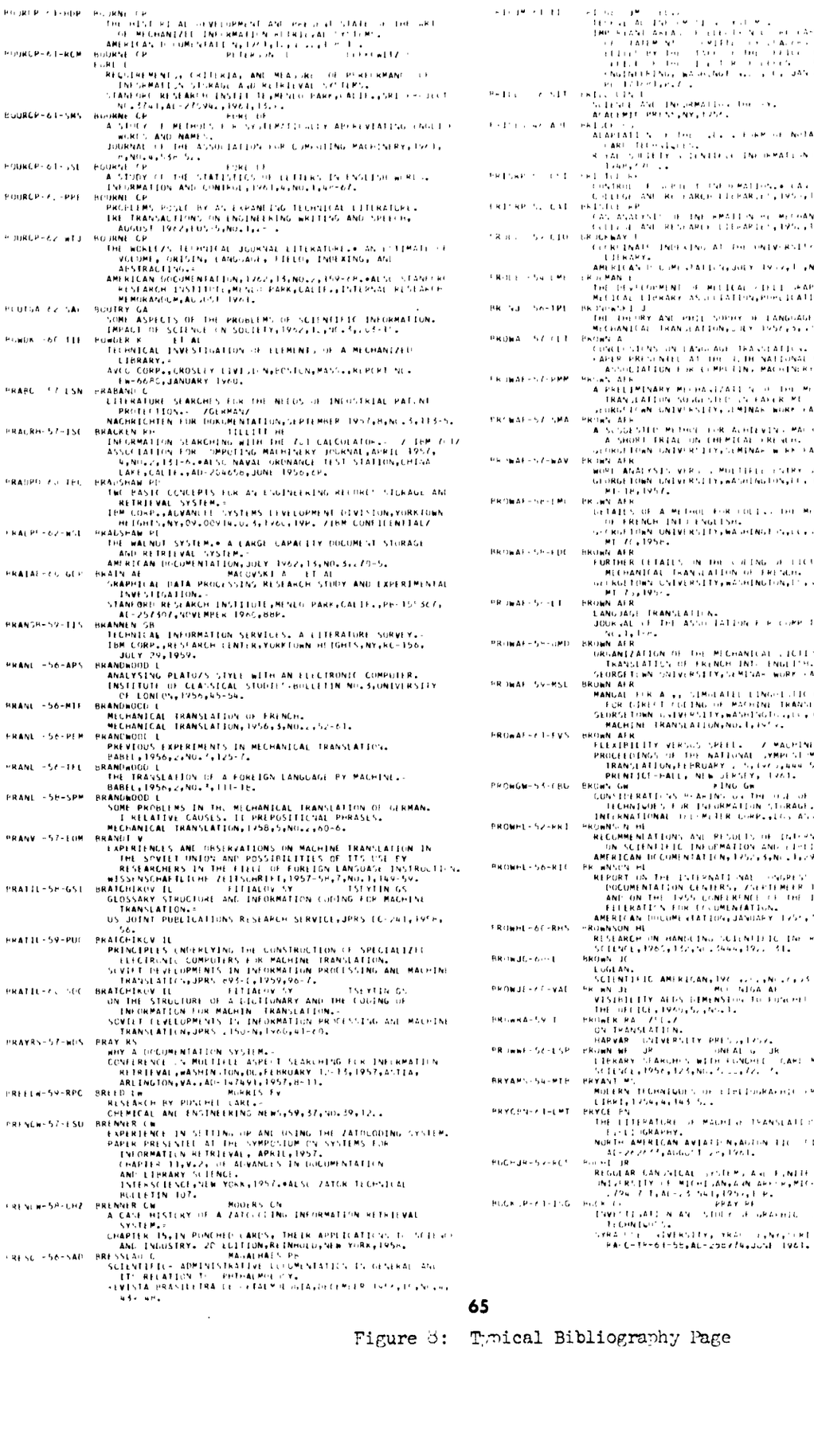
HALLENGE OF INFORMATION RETRIEVAL, THE C FAIRJ, ...
MECHANIZED INFORMATION RETRIEVAL,- TEXTBOOK ON KENTA, ...
FICATION IN INFORMATION RETRIEVAL,- THE FUNCTION OF CLASSI VICKPC, ...
OMPUTER IN MEDICAL DATA RETRIEVAL,- USES OF THE C LEDER, ...
INFORMATION STORAGE AND RETRIEVAL,- A STUDY OF THE FUNDAMENT WORSPR, ...
INFORMATION FOR MACHINE RETRIEVAL,- NETRITION,- A SCHEME FOR LEITT, ...
INFORMATION STORAGE AND RETRIEVAL,- APPLICATIONS OF COMPUTER NOZZA3, ...
MENT IDENTIFICATION AND RETRIEVAL,- PROBABILISTIC INDEXING,- MAKOME, ...
INFORMATION STORAGE / RETRIEVAL,- BUSHWE, ...
WALNUT FOR INFORMATION RETRIEVAL,- TOZ0A5, ...
ASPECTS OF INFORMATION RETRIEVAL,- SOME CLEVCW, ...
THE PATTERNS OF RETRIEVAL,- FAIRRA, ...
INFORMATION STORAGE AND RETRIEVAL,- PERSPECTIVES IN HATTEH, ...
ADAPTIVE INFORMATION RETRIEVAL,- KOCHM, ...
ASPECTS OF INFORMATION RETRIEVAL,- COMBINATORIAL MARITM, ...
OBLEMS OF DOCUMENTATION RETRIEVAL,- SURVEY OF PR OROSS, ...
ARCHING FOR INFORMATION RETRIEVAL, MULTIPLE ASPECT SE TEC709, ...
AL TEXT FOR INFORMATION RETRIEVAL, COMPUTER SEARCHING OF NO MAGNJJ, ...
INFORMATION STORAGE AND RETRIEVAL, / SDIC / A COMPUTER-INTEGR TRITRJ, ...
APPROACH TO INFORMATION RETRIEVAL,- A RATIONAL WEISKC, ...
INFORMATION RETRIEVAL,- /ANNOTATED-BIBLIOGRAPHY/ TOZ5A8, ...
CONCEPTS OF INFORMATION RETRIEVAL,- UNIVAC DATA AUTOMATION S TURAWJ, ...
INFORMATION RETRIEVAL,- /MOVIE/ VOOIA1, ...
INFORMATION RETRIEVAL, WILLT, ...
OCUMENT AND INFORMATION RETRIEVAL,- A PHOTO- MAGNETIC SYSTEM JAMEP, ...
INFORMATION STORAGE AND RETRIEVAL,- / BIBLIOGRAPHY/ TOZ4A5, ...
T IN AUTOMATIC DOCUMENT RETRIEVAL,- / IBM-705/ /FRENCH/ AN E PICOG, ...
METHODS OF INFORMATION RETRIEVAL,- THE NEED FOR A FACETED C TOZ5AN, ...
F TOOLS FOR INFORMATION RETRIEVAL,- PRESENTLY AVAILABL RAPIJ, ...
N AUTOMATED INFORMATION RETRIEVAL,- THE NEED FOR A THESAURUS HALZEF, ...
ICATION FOR INFORMATION RETRIEVAL,- CLASSIFICATION AT DORKIN SHERJH, ...
INFORMATION RETRIEVAL,- / IBM 1620/ CAMMS, ...
INFORMATION RETRIEVAL, KENTA, ...
E MECHANIZATION OF DATA RETRIEVAL,- IH TAUBM, ...
TOWARDS INFORMATION RETRIEVAL,- /BOOK-REVIEW/ WICKBC, ...
T NEEDS FOR INFORMATION RETRIEVAL,- EQUIPMEN WARHIA, ...
INFORMATION RETRIEVAL,- NOZ6A7, ...
ICATION FOR INFORMATION RETRIEVAL,- INTERNATIONAL STUDY CONF NOZ7A1, ...
ARCH STRATEGY FOR LEGAL RETRIEVAL,- A SE TOZ4A5, ...



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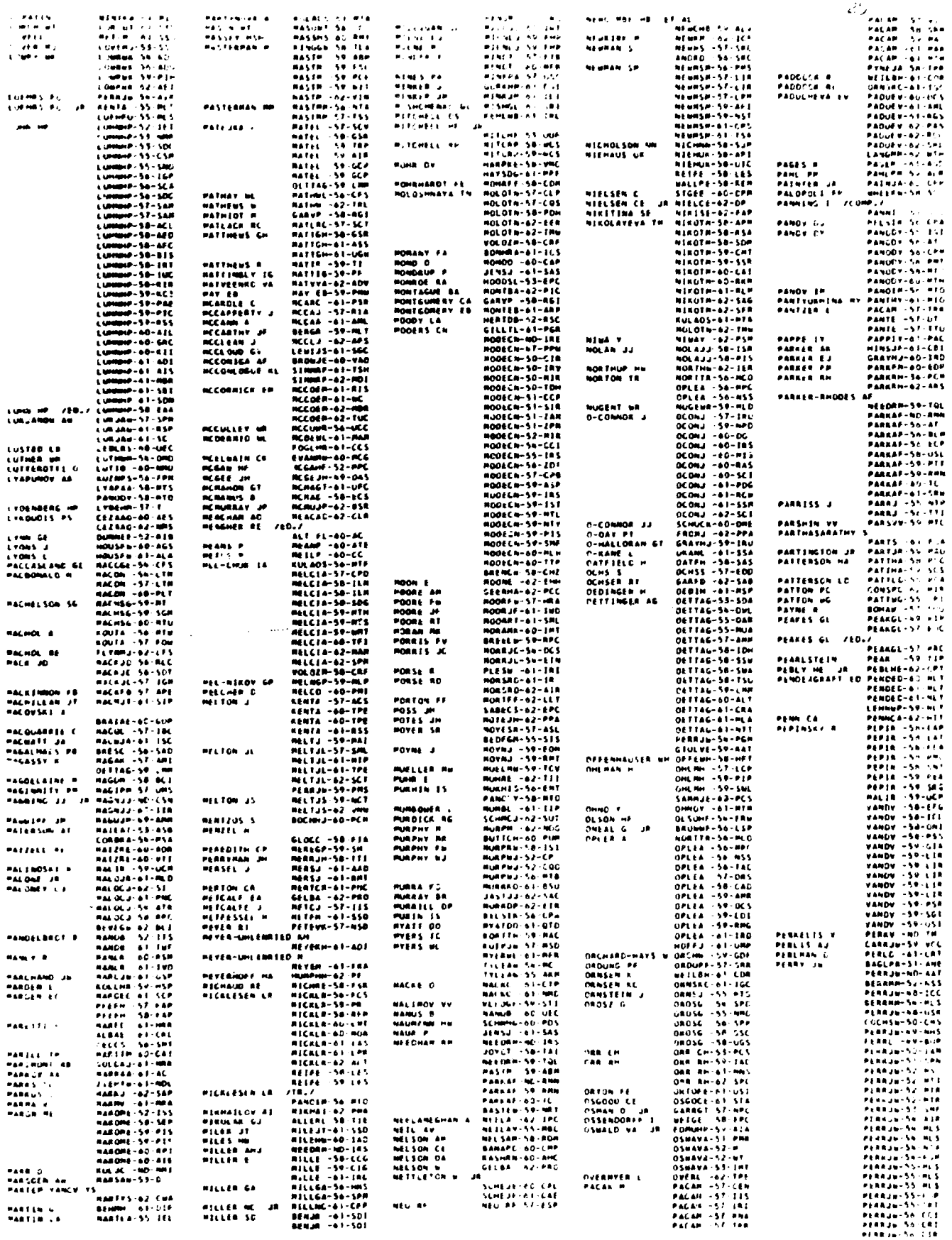


115.

Figure 9: KWIC Author Index Page

A typical reference code is shown in Figure 7. It consists of the first four letters of the author's last name, his first two initials, the last two digits of the year of publication, and the initial letters of the first three words of the title of his document. (The following words are disregarded: the, of, in, from, by, at, as, and, an, a, on, or, to, with, for.) The choice of the composition of the reference code is practically unlimited, however. It may be assigned on the basis of report numbers, patent numbers, some arbitrary numbering system, characteristics of the document concerned, or even on the order in which the bibliographical entries are to appear.(44)

Computer manufacturers offer on request detailed instructions, programs and other essential data necessary for producing KWIC indexes. No attempt will be made here to duplicate their effort. The intricate data processing techniques inherent in the preparation of KWIC indexes do not conform with nor advance the aims of this thesis which are rather to subjectively evaluate this mode of indexing and to statistically test the hypothesis upon which it is based. Before concluding the general description of KWIC indexing, however, it is worth noting that in order to produce a KWIC index of titles, bibliographical entries consisting of at least, title, author and source are recorded in machine-readable form, such as punched cards, so that computer processing can produce the printed index with its bibliographical data. The cards making up the master record bibliography, the special word list, and the KWIC program constitute the input to the computer (see Figure 10). Upon processing, the computer determines the status (keyword or common) of each word in a document title by looking it

up in the stop list. All ordering and arranging of the input information is performed by the computer. A magnetic output tape containing the final arrangement of the KWIC index, the bibliography and the author index is fed through a printout device to produce copy for subsequent reproduction. (45)

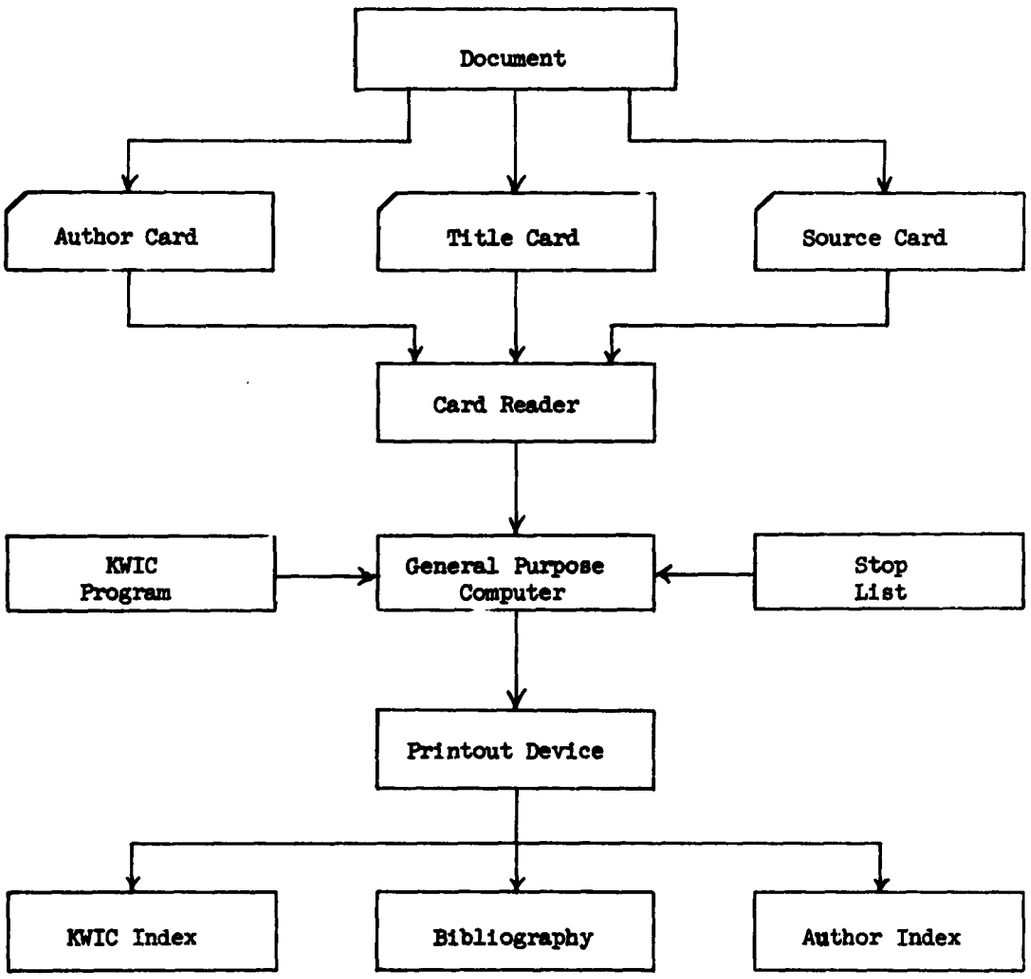


Figure 10: Generation of KWIC Index

III. STUDY OF ADEQUACY OF TITLES AS SEARCH TOOLS

A. General

"If the (KWIC) index is based on titles of documents, its quality depends on how well the authors have composed the titles of their papers", with these words H. P. Luhn almost matter-of-factly stated the hypothesis upon which KWIC indexing is based.(46) Essentially, then, the efficacy this mode of indexing is dependent upon whether titles are in fact descriptive. Those who assail KWIC indexing claim that titles are not descriptive, or at least not sufficiently descriptive to merit serious consideration as sources of index entries; its exponents claim the converse. The natural result of this debate has been several studies aimed at assessing the adequacy of titles as search tools.

A study by Montgomery and Swanson showed that "the present indexing of medical literature as published in Index Medicus is, or could be, based largely on examination of titles and word-plus-synonym match of titles to subject headings." Titles were found to be about 50 per cent effective as a basis for judging the relevance of an article to a given information need.(47)

Maizell found that in a sample of 25 articles, included both in Physics Abstracts and Chemical Abstracts, the titles alone contained about 50-70 per cent of the key terms under which the articles were indexed.(48),(49)

In the area of legal literature, Kraft examined 3428 titles from legal research projects, theses and the Index to Legal Periodicals. His findings, among other things, revealed that 64.4 per cent of the title entries contained as keywords one or more of the subject heading words

under which they were indexed; and 25.1 per cent contained logical equivalents. The remaining 10.5 per cent of the title entries had non-descriptive titles. He concluded that a KWIC index of legal titles produces an index which costs less than a subject heading system in both time and cost of production and which ranks high in "findability."(50)

It seems intuitive to this author that highly descriptive titles will, in the main, be found in the technical fields of science and engineering and that less descriptive, or the least descriptive titles, will be found in the social sciences and humanities. As stated this is intuition, and regardless of its plausibility, it is an untested premise. This author decided to test the premise by examining titles from several fields, principally science and engineering, and in so doing continue the overall research effort at determining the adequacy of titles as search tools. In this regard, Kraft's study provided a worthy guide and reasonable point of departure - his procedure was modified slightly for this research. Six published indexes to periodical literature provided the source of titles for the study and the findings for each will be discussed in detail after the following description of the procedure employed.

B. Procedure

The scope of this study as indicated by the following list, spans the subject fields of science, engineering, social science and the humanities.

Index	Subject Field
Engineering Index	Engineering and Science
Applied Science and Technology Index	Engineering and Science
ASM Review of Metal Literature	Engineering and Science
Public Affairs Information Science, Annual Cumulated Bulletin	Economics and Information
Business Periodicals Index	Business
International Index	Social Science and Humanities

In each instance the most recent annual index was chosen on the assumption that each index mirrors the most current periodical literature in its respective field.

From each of these indexes a genuine random sample was taken. Randomness was achieved using numbers taken from tables of random numbers, initially. Later, to expedite the process of locating a desired title, random numbers were computer generated within limits, the limits being the total number of pages in the particular index and the maximum number of titles per page. Randomness was maintained in order that statistical inferences with a desired level of precision might be made from sample data. In this respect previous studies lacked precision or confidence limits because sampling was not conducted statistically.

After each title was randomly chosen, keywords were selected from it by the author using the rules under which a computer would have operated. All words were considered keywords with the exception of stoplist articles, prepositions, conjunctions and other "common" words (the stoplist was previously discussed). For purposes of analysis the titles were, in the context of acceptance sampling, considered as either effective (KWIC-able) or defective (not KWIC-able). Beyond this major dichotomous classification, the KWIC-able titles were grouped into four types. For a graphic illustration

of the logic used in sorting titles, see Figure 11. The examples which follow use titles from the Engineering Index (EI).

TYPE 1: A title which contains a keyword exactly or in some root form as a word in a subject heading of the index.

Examples:

EI Heading: FUEL CELLS

Title: "Fuel Cells and Their Effects on Utilities"

EI Heading: THERMODYNAMICS

Title: "'Laxation' Function Makes Entropy Easier to Understand"

The first title has a word which is the exact same as the subject heading under which it is indexed. The second title has a word "Entropy" which is a subject heading in the Engineering Index, however, "entropy" has a "see" reference to "Thermodynamics". In either case the title contains a keyword exactly or in some root form as a word in a subject heading of the index.

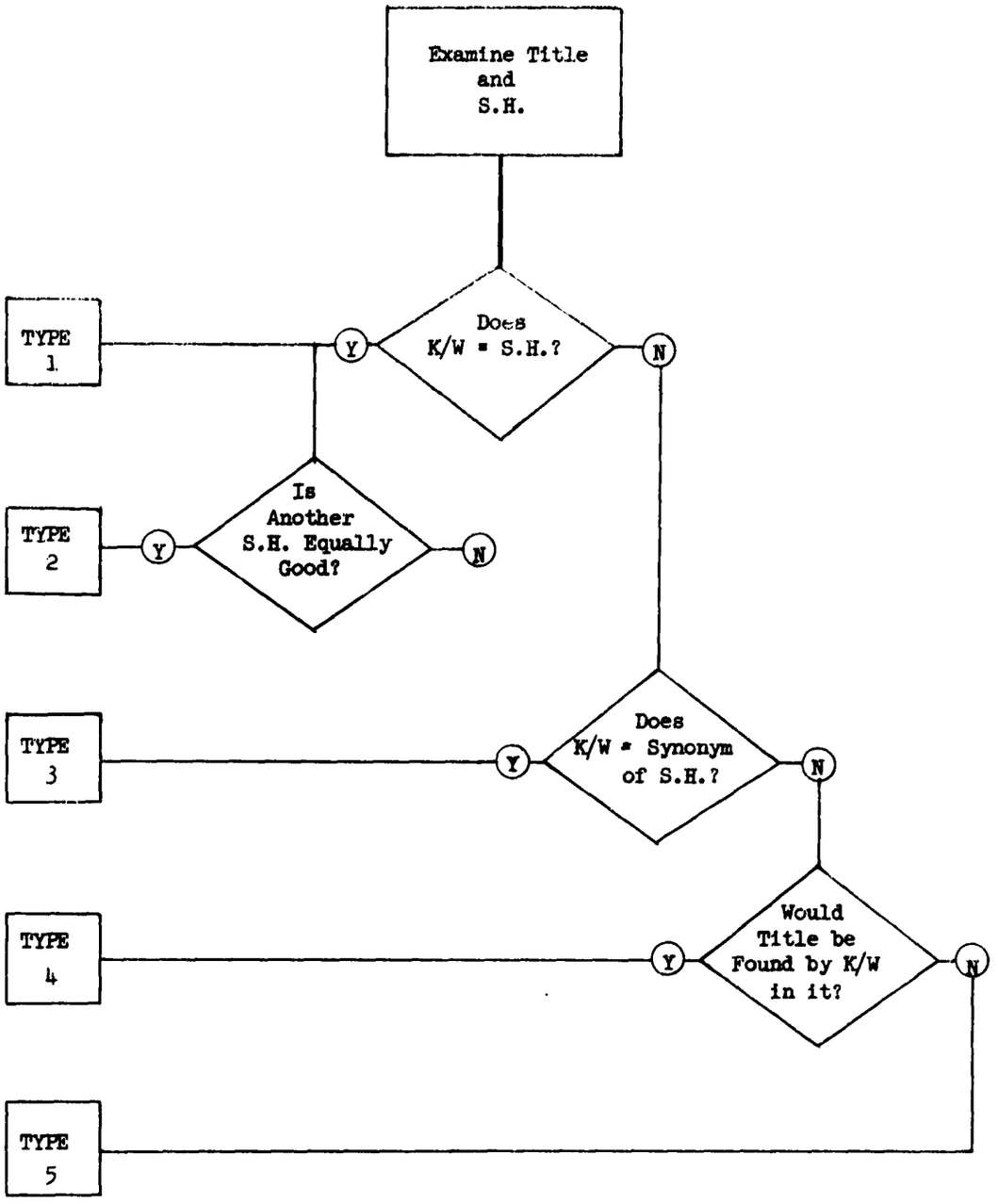
TYPE 2: A Type 1 title which could have been indexed equally well under another subject heading which appears in the title.

Example:

EI Heading: PYROMETRY and OPEN HEARTH FURNACE

Title: "Immersion Pyrometry and Open Hearth Furnace Productivity"

Titles of this type are even more "findable" than those of Type 1, hence very KWIC-able.



S.H. = Subject Heading
K/W = Any Keyword in Title

Types 1,2,3, & 4 = Effective Titles
Type 5 = Defective Titles

Figure 11: Logic Followed in Sorting Titles by Type

TYPE 3: A title not classified 1 or 2 but which contains a synonym of its subject heading:

Examples:

EI Heading: PLUTONIUM or URANIUM

Title: "Simultaneously Determining Pu and U in Dissolver Samples"

EI Heading: AUTOMOBILE

Title: "Atomic Age Car Concept"

This classification includes few titles because it is limited to abbreviations as in the first title and bona fide synonyms as in the second title.

TYPE 4: A title not of Types 1, 2 or 3, but which contain keywords that would enable an informed researcher to find it in an obvious manner under a KWIC indexing system.

Example:

EI Heading: HYDROCARBONS, PROCESSING

Title: "Isomerization or Normal Pentane over Platinum Alumina Catalysts"

EI Heading: SPACE VEHICLES, COMMUNICATIONS SYSTEMS

Title: "Transmission of Electromagnetic Waves through Ionized Layer in Presence of Strong Magnetic Field"

As Kraft points out, titles such as these, illustrate the problem inherent in all subject heading systems: How can the searcher "outguess" the

indexes. These titles would be lost if the searcher failed to think of the subject headings "Hydrocarbons, Processing" and "Space Vehicles, Communications Systems"; also the titles were not indexed under any other related subject headings. A KWIC index, however, would index the titles under each of the underlined words, some of which are very descriptive, making them a cinch to find. (51)

TYPE 5: A title not of Types 1, 2, 3 or 4. This is the class of non-descriptive ("defective" in acceptance sampling context) titles.

Examples:

EI Heading: MOTOR SHIPS

Title: "Nordvind"

EI Heading: PETROLEUM PROSPECTING, OKLAHOMA and TEXAS

Title: "Major Play Shaping Up in Palo Duro"

Admittedly this classification scheme is subjective, not so much in separating Types 1 and 2 titles (this is simply a matter of determining the presence or absence of a subject heading for each keyword in the title), but certainly in sorting titles into Types 4 and 5. The author attempted to be unbiased, if indifferent, in the sorting process. Whenever there was reasonable doubt about how to classify a title it was placed in that group which was least advantageous for proving a case for KWIC indexing. (52)

Now that the procedure has been elucidated, the sampling from each index will be discussed in turn.

C. Engineering Index Sample

1. General

The Engineering Index is published annually by Engineering Index, Inc., 345 East 47th Street, New York 17, New York, which "indexes and annotates, selectively, on the basis of engineering significance, the available current technical periodicals received by and permanently housed in the Engineering Societies Library. Included are the regular professional and trade journals, publications of engineering societies, scientific and technical associations, universities, laboratories and research institutions, government departments and agencies, and industrial organizations. Papers of conferences and symposia, separate and non-serial publications of various kinds, and selected books are also covered. Patents are excluded."(53)

The particular issue chosen was 1962; it includes approximately 31,000 brief abstracts of articles from 1000-odd periodicals and serial publications reviewed. As stated previously it is considered by the author to contain a representative sampling of titles from the fields of science and engineering.

The Engineering Index lists each title only once, under what is presumed to be the most appropriate subject heading, but makes liberal use of the "see" and "see also" reference.

2. Estimation of Sample Size

Before the statistical sample could be performed on this index it was necessary to first get some indication of the required size of the

sample. In probability sampling the size of the sample can be determined mathematically once the desired precision and estimated variability of the result is decided.

With respect to sampling titles from the index, recall that the titles are sorted into two broad classes, KWIC-able and not KWIC-able. For purposes of computation, Q represents the proportion of KWIC-able titles, P represents the proportion of not KWIC-able titles, and p is the estimated proportion of P from the sample. The author chose a margin of error d in the estimated proportion p of titles in P and willingly incurred the small risk α that the actual error was larger than d; that is,

$$\Pr\ (\,|p - P| \geq d) = \alpha \qquad (1)$$

Again, simple random sampling was assumed; p was taken as normaly distributed. Since the sample (n) is very small in proportion to the total number of titles in the index (N), the standard deviation of p is,

$$\sigma_p = \sqrt{\frac{PQ}{n}} \qquad (2)$$

Hence the formula that connects n with the desired degree of precision is,

$$d = t\sqrt{\frac{PQ}{n}} \qquad (3)$$

where t is the abscissa of the normal curve that cuts off an area at the tails. Substituting the advance estimate p for P and solving for n, yields,[94]

$$n = \frac{t^2\,pq}{d^2} = \frac{p\,q}{V} \qquad (4)$$

where $V = \frac{d^2}{t^2}$ = desired variance of the sample proportion.

Next the author set the precision requirements consistent with the critical result. Parenthetically, the critical result in any study is that result requiring the greatest sample size to achieve the desired precision in view of the estimated variability.[55], [56] Briefly, the specification of precision is that p is to lie in the range $(P \pm 2.5)$, except for a 1 in 20 chance. Kraft's work is used as a basis for an advance estimate p of P. Thus,

$$d = .025, \qquad p = .10, \qquad \alpha = .05, \qquad t = 1.96$$

and

$$n = \frac{t^2 p q}{d^2} = \frac{(1.96)^2(.10)(.90)}{(.025)^2} = 550 \qquad (5)$$

It is worth noting at this point that 550 is an estimate of sample consistent with desired precision and advance estimate, p, of population proportion defective, P. As it turned out, upon sampling from the Engineering Index, the number of not KWIC-able titles was so few that the advance estimate of 10% defective titles proved to be disproportionate, hence all sampling was terminated after 390 titles had been examined.

3. Classification

The results of the sorting of titles are in the table below:

Type	"1"	"2"	"3"	"4"	"5"	Total
Number	324	124	8	50	8	390
% of Total	83.1*	31.8	2.05	12.8	2.05	100.0

* The reader should recall that Type 1 titles include Type 2 titles.

4. Confidence Limits

Since n p, or more specifically the number of titles observed in the smaller (defective) class, is small, only 8 and less than 10% of sample size, Duncan[57] states that the binomial distribution is better approximated by the Poisson distribution than the normal distribution in setting up confidence for P. Confidence limits may be determined for this case in a variety of ways such as the Thorndike Chart, Molina's Table II or Dodge and Romig's Tables. The author took Cochran's suggestion, however, and used Table VIII_1 in Fisher and Yates' Statistical Tables (1957) which "gives binomial confidence limits for P for any value of n, and is a useful alternative to the ordinary binomial tables."[58] The applicable portion of Table VIII_1 is included in order to illustrate the calculation of the confidence limits for P.

a	p a/N	Probability P of 'a' or more .005	.025	.1	Probability P of 'a' or fewer .1	.025	.005
8	.5	3.04	3.94	5.09	10.91	12.06	12.96
	.4	2.92	3.82	4.98	11.35	12.79	14.02
	.3	2.82	3.72	4.89	11.77	13.52	15.10
	.2	2.73	3.62	4.80	12.18	14.26	16.22
	.1	2.65	3.53	4.73	12.59	15.01	17.37
	0	2.57	3.45	4.66	12.99	15.76	18.58

To obtain the limits of the probability of an event (observed to occur 'a' times out of N) corresponding to a given probability level P, divide the tabulated values by N, first interpolating if necessary by linear interpolation with reference to P = a/N. The limits of the expectation of Poisson distributions are given directly, taking p = 0.

The limits for the probability of 8 defective titles occurring in a sample of size 390 may be gotten from the table directly. Taking p=0, the limits are 3.45 and 15.76 as circled above. Thus the 95% limits for P are estimated as:

$$\hat{P}_L = \frac{3.45}{390} \times 100\% = .885 \text{ per cent}$$

$$\hat{P}_u = \frac{15.76}{390} \times 100\% = 4.04 \text{ per cent}$$

From which it may be said that there is a very good chance, a 95% probability in fact, that the proportion of defective or not KWIC-able titles in the Engineering Index falls within the interval from .885 to 4.04 per cent.

Next confidence limits were determined for the Type 1 titles — those titles having at least one keyword exactly or in some root form as a subject heading in the Index. Now, however, the fraction defective, in this instance the fraction of Type 1 titles, is larger than 10% such that the Poisson distribution and the very convenient Fisher and Yates Table VIII_1 no longer apply. Duncan points out that in this case the binomial distribution can be approximated reasonably well by a normal distribution with a mean equal to p and a standard deviation equal to $\sqrt{\frac{p\,q}{n}}$.(59) Thus the 95% limits for Type 1 titles are

$$83.1 \pm 1.96\sqrt{\frac{(83.1)(16.9)}{390}} = 83.1 \pm 3.72 \qquad (6)$$

$$\hat{P}_L = 79.3 \qquad \hat{P}_u = 86.7$$

This simply means that there is a 95% chance that the proportion of titles in the Engineering Index having at least one keyword exactly or in some root form as a subject heading in the Index will fall within the interval from 79.3 to 86.7 per cent.

Comments concerning the implications of this sample and the attendant confidence limits are being withheld until all sample data is presented. This permits a graphical compilation and a comparison of results.

D. Applied Science and Technology Index Sample

1. General

Applied Science and Technology Index is published monthly by H. W. Wilson Company, 950 University Avenue, New York 52, New York. This publication classified engineering and science articles according to a subject heading system, including hundreds of headings such as Ablation, Aeration, Iodides, Magnetism, Polarograph, Transistors and Zwitterions.

The particular issue chosen was the 1962 annual cumulated index. The Applied Science and Technology Index indexes engineering and science articles from some 215 publications. This issue contained 1313 pages with 55-60 titles per page or some 75,000-odd bibliographic citations; however, since an article may be indexed under more than one subject heading, it is not known how many distinct titles the volume includes.(60)

No estimate of sample size was computed for sampling this index, the experience gained in sampling from the Engineering Index led the author to adopt a wait and see attitude; the assumption being that since both indexes are concerned with engineering and science that results should be similar. Sampling was terminated after 600 titles had been examined.

2. Classification

Type	"1"	"2"	"3"	"4"	"5"	Total
Number	176	135	2	15	7	200
% of Total	88	67.5	1.0	7.5	3.5	100.0

3. Confidence Limits

Using Fisher and Yates again the 95% confidence limits for P are estimated as:

$$\hat{P}_L = \frac{281}{200} = 1.4, \qquad \hat{P}_u = \frac{1442}{200} = 7.2$$

Also the 95% limits for Type 1 titles are:

$$\frac{176}{200} \pm 1.96\sqrt{\frac{(88)(12)}{200}} = 88 \pm 4.5 \qquad (7)$$

$$\hat{P}_L = 83.5, \qquad \hat{P}_u = 92.5$$

E. Metal Literature Sample

1. General

ASM Review of Metal Literature is published monthly by the American Society for Metals, Metals Pack, Ohio. It is "an annotated survey of articles, technical papers and reports appearing in engineering, scientific and industrial journals and books, here and abroad."(61) This index professes to index based on the content of the article and not merely

on the title. To accomplish this a deeper and more detailed analysis of subject content is performed and more flexible cross-referencing is employed.

The particular issue chosen was Vol. 19, January-December 1962. This particular issue contained approximately 12,800 indicative abstracts from 900-odd publications. The author chose to sample from this index because it embraced a far more specific subarea, metal literature, of science and engineering. It was assumed that this index would yield even better results, that is, fewer defective titles.

2. Classification

Type	"1"	"2"	"3"	"4"	"5"	Total
Number	103	67	0	17	0	120
% of Total	86	56	0	14	0	100.0

3. Confidence Limits

Using Fisher and Yates again, the 95% confidence limits for P are estimated as:

$$\hat{P}_L = 0, \qquad \hat{P}_u = \frac{369}{120} = 3.08$$

And the 95% limits for Type 1 titles are:

$$\frac{103}{120} \pm 1.96 \sqrt{\frac{(86)(14)}{120}} = 86 \pm 6.22 \qquad (8)$$

$$\hat{P}_L = 80.0, \qquad \hat{P}_u = 92.2$$

F. Public Affairs Information Service Sample

1. General

The Public Affairs Information Service, Annual Cumulated Bulletin is published by Public Affairs Information Service, Inc., 11 West 40th Street, New York, New York, 10018. "Its purpose is the publication of a weekly Bulletin, listing by subject current books, pamphlets, periodical articles, government documents, and any other useful library material in the field of economics and public affairs. The Bulletin is not primarily an index to periodicals, though selected articles in more than one thousand periodicals are listed each year. Publications of all kinds from all English-speaking countries are included, as well as many printed in English in other countries. Emphasis is placed upon factual and statistical information. Works in foreign languages are not mentioned." (62)

This index or bulletin was chosen by the author as a first step in evaluating titles outside of the fields of engineering and science. The particular issue selected was Vol. 48, October 1962-September 1963 which included 845 pages of brief annotations with approximately 33,000 distinct titles. No attempt was made to predetermine a sample size; it was arbitrarily set by the author at 300. Further, because of the extra time involved in the additional look-up required of Type 2 titles, the Type 2 classification was dropped. Obviously titles which would have appeared under this classification still appear as Type 1 titles.

2. Classification

Type	"1"	"2"	"3"	"4"	"5"	Total
Number	166	-	10	113	11	300
% of Total	55.3	-	3.3	37.7	3.7	100.0

3. Confidence Limits

Using Fisher and Yates, the 95% confidence limits for P are:

$$\hat{P}_L = \frac{550}{300} = 1.83, \qquad \hat{P}_u = \frac{1965}{300} = 6.55$$

The 95% limits for Type 1 titles are:

$$\frac{166}{300} \pm 1.96\sqrt{\frac{(55.3)(44.7)}{300}} = 55.3 \pm 5.63 \qquad (9)$$

$$\hat{P}_L = 49.7, \qquad \hat{P}_u = 60.9$$

G. Business Periodicals Index

1. General

The Business Periodicals Index is published monthly by H. W. Wilson Company, 950 University Avenue, New York 52, New York. This publication indexes 118 periodicals in the fields of accounting, advertising, bank and finance, insurance, general business, labor, marketing public administration and taxation. Its citations are bibliographic and the particular issue chosen, which included material from July 1962 through

June 1963, contained approximately 49,000 entries.(63) It is not known how many distinct titles the volume includes because articles may be indexed under more than one subject heading.

As with the previous index, the author arbitrarily set sample size, in this case at 510. Also the Type 2 classification was dropped.

2. Classification

Type	"1"	"2"	"3"	"4"	"5"	Total
Number	229	-	38	164	79	510
% of Total	45.0	-	7.5	32.0	15.5	100.0

3. Confidence Limits

Now however the fraction defective is larger than 10%, therefore the normal approximation to the binomial distribution was employed. Thus the 95% confidence limits for P are:

$$15.5 \pm 1.96\sqrt{\frac{(84.5)(15.5)}{510}} = 15.5 \pm 3.15 \qquad (10)$$

$$\hat{P}_L = 12.4, \qquad \hat{P}_u = 18.7$$

The 95% limits for Type 1 titles are:

$$\frac{229}{510} \pm 1.96\sqrt{\frac{(45)(55)}{510}} = 45.0 \pm 4.33 \qquad (11)$$

$$\hat{P}_L = 40.7, \qquad \hat{P}_u = 49.3$$

H. International Index Sample

1. General

The International Index is published quarterly by H. W. Wilson Company, 950 University Avenue, New York 52, New York. It is a guide to periodical literature in the social sciences and humanities and as such was the most generic body of titles which the author examined.

The particular issue chosen was the annual cumulated index consisting of bibliographic citations of articles appearing in 173 international periodicals from April 1962 through March 1963. As with previous Wilson volumes, it is not known how many distinct titles are included because titles may be indexed under more than one subject heading. (64)

Again due to time constraints, the author set sample size at 510 and dropped the Type 2 classification.

2. Classification

Type	"1"	"2"	"3"	"4"	"5"	Total
Number	164	-	8	225	113	510
% of Total	32.2	-	1.5	44.2	22.1	100.0

3. Confidence Limits

Using the normal approximation again, the 95% limits for P are:

$$22.1 \pm 1.96 \sqrt{\frac{(22.1)(77.9)}{510}} = 22.1 \pm 3.66 \qquad (12)$$

$$\hat{P}_L = 18.4, \qquad \hat{P}_u = 25.8$$

The 94% limits for Type 1 titles are:

$$\frac{164}{510} \pm 1.96\sqrt{\frac{(32.2)(67.8)}{510}} = 32.2 \pm 4.06 \qquad (15)$$

$$\hat{P}_L = 27.9, \qquad \hat{P}_u = 36.1$$

I. Interpretation of Data

The results of the preceding six samples are compiled in Table I, page 48.

At a glance it is obvious that titles within the fields of engineering and science are very effective or KWIC-able, beyond all expectation as far as the author is concerned. There is, in fact, a 95% probability that a vast percentage, between 79.3 and 92.2 per cent (the lower confidence limit of the Engineering Index and the upper confidence limit of the Applied Science and Technology Index), of the titles within these fields are Type 1 titles.

The Applied Science and Technology Index has the largest percentage (83.5 to 92.5 per cent confidence interval) of Type 1 titles. The author feels that this is due to the fact that titles may be indexed under more than one subject heading and that this index has the largest number of subject headings per se. The author offers no factual evidence to verify the latter comment; however, the fact that this index has the largest number of Type 2 and smallest number of Type 4 titles, seems to substantiate the observation.

The preponderance of Type 1 and 2 titles might suggest that indexers in the fields of engineering and science, either intentionally or unwittingly,

	TYPE	1			2	3	4	5			Total
ENGINEERING INDEX	Number	--	324	--	124	8	50	--	8	--	390
	% of Total & Conf. Limits	79.3	83.1	86.7	31.8	2.05	12.8	.89	2.05	4.04	100.0
AP. SC. AND TECH. INDEX	Number	--	176	--	135	2	15	--	7	--	200
	% of Total & Conf. Limits	83.5	88	92.5	67.5	1.0	7.5	1.4	3.5	7.2	100.0
ASM REVIEW	Number	--	103	--	67	0	17	--	0	--	100
	% of Total & Conf. Limits	80.0	86	92.2	56	0	14.0	0	0	3.1	100.0
BULLETIN PAIS	Number	--	166	--	--	10	113	--	11	--	300
	% of Total & Conf. Limits	49.7	55.3	60.9	--	3.3	37.7	1.83	3.7	6.55	100.0
BSNS. PERIOD. INDEX	Number	--	229	--	--	38	164	--	79	--	510
	% of Total & Conf. Limits	40.7	45.0	49.3	--	7.5	32.0	12.4	15.5	18.7	100.0
INTERNATL INDEX	Number	--	164	--	--	8	235	--	113	--	510
	% of Total & Conf. Limits	27.9	32.2	36.1	--	1.5	44.2	16.4	22.1	28.3	100.0

Table I: Compilation of Data

use titles as a basis for originating subject headings. This fact, if so, adds substantial support for KWIC indexing, because KWIC indexing, in contrast to human indexing, can be done by machines with little physical and infinitesimal intellectual effort being required.

That the ASM Review sample yielded no defective titles came as no surprise to the author. It was apparent while conducting the sample that this index bases its analysis on the content of the article and not merely on the title - something which was not apparent in the other samples. The author concluded that the ASM Review indexes metal literature throughly and deeply. Further, it and the Applied Science and Technology Index actually had more Type 2 titles than Type 1.

Comparison or contrast of the width of the confidence intervals for Type 1 titles in the engineering and science fields yields little because the sample sizes are unequal. In this instance the width of the intervals is not related to proportion of Type 1 titles but to sample size.

In the engineering and science area the percentage of defective titles was least in the ASM Review sample, increased in the Engineering Index sample and increased again in the Applied Science and Technology sample. The author feels that this order is plausible, if predictable. Assuming identical analysis, in this case KWIC indexing, the percentage of defective or not KWIC-able titles in a file of documents, even an amorphous file, is inversely proportional to the degree of technicality or, better stated, the technical character of the documents themselves.

The small number of not KWIC-able titles in the Public Affairs and Information Service sample came as a surprise to the author, for it imputes

a technical character to titles of documents in fields (economics and public affairs) which are unquestionably vastly less technical "in the usual sense" than science and engineering. "In the usual sense" deserves discussion. Technical in the usual sense has come to delimit the use of the word technical to science and in particular engineering. This is erroneous; technical may apply to any highly specialized field. In this sense medicine, law, the priesthood as well as the Navy and many trades are technical. Frequently such fields have languages or lingos which the non-cognoscenti find confusing or unintelligible. Jargon-filled titles from such fields, however, are exceedingly specific and descriptive for the profession or trade-oriented searcher. It is in this context that titles from the Public Affairs and Information Service Bulletin rank so high in findability. Its source material is indeed technical in character, much of it being the outputs of congressional committees, governmental departments and other bureaucratic agencies which characteristically title their exudations with balefully scientific and/or onerously long, but nonetheless descriptive, titles.

The International Index sample indicates the woeful lack of descriptive titles in the social sciences and humanities. Here authors employ metaphor, simile, metonymy, synecdoche and other unpronounceable artifices to be cleverly non-descriptive. For example, the title,"Saints and Sinners in Foreign Investment", which appeared under the subject heading, "Foreign Investment" contains metaphor, but remains descriptive and KWIC-able. Thus some artful languages in titles is tolerable. On the other hand titles such as "Milestone", "The Greeks Had a Name for It", and "Squeezplay" are

hopelessly non-KWIC-able in their present form. The author is not suggesting that all titles be descriptive. On the contrary, the figurative use of words in non-technical and transient literature is refreshing and desirable. Still, figurative ploys in titling are the bane of machine indexing as this sample and the Business Periodicals Index sample, which was little better, readily illustrate.

In summary this study reveals that a KWIC index, based on keywords which appear in the title alone will index documents in the fields of engineering and science in the same way as would a human between 79.3 and 92.5 per cent of the time, and also that the largest proportion of not KWIC-able titles sampled was a mere 3.5 per cent. Further, KWIC indexing is suitable for any highly specialized field (the more that it is jargon-filled the better), not just engineering and science. Clearly the adequacy of titles as search tools in any highly specialized field is certain. Finally the less specialized the field (as in social science and the humanities), the less descriptive titles are and the less effective KWIC indexing is.

IV. PROS AND CONS OF KWIC INDEXING

A. General

Up to this point this protracted discourse has embraced the background of KWIC indexing, a description of it and a complete evaluation of the hypothesis -- that titles are adequate search tools -- upon which it is based. However, without a discussion of the pros and cons of KWIC indexing, previous effort is singularly incomplete. This chapter is aimed at such a discussion and advantages shall be enumerated first.

B. Advantages

1. Heretofore this thesis has discussed KWIC indexing as applied to titles of documents. It may, however, be carried out on various levels, depending on the purpose an index is to serve. The process may be applied to either the title, abstract or entire text of a document.

2. Words of titles are ordered in their original sequence so that the reader has little difficulty in grasping the content of the document which the words describe. In printed form the indexes can be searched rapidly by eye, so that the need for machines in the retrieval phase is largely obviated.

3. The machine will index a document many other ways, the exact number of entries depending on the number of keywords in the title. This redundancy improves the probability of finding desired references, since the number of access points for conducting a search are increased. Certainly a human would index under multiple subject headings. It is doubtful though that he would use as many entries as a computer.

4. One of the major advantages of KWIC indexing is its flexibility. If the title does not adequately describe the content of a document, descriptive words may be editorially added to improve title significance. Further, such words can be made to act as keywords under which the title will be indexed or they may function as stoplist words, which appear each time a title is indexed but which themselves do not become index entries. When the situation arises, editorial revisions may be made either to prevent unwanted terms from indexing or to index more than one part of some words. For example, the word mucopolysaccarides could be indexed under muco, poly and saccarides in order to give researchers more than one approach to the subject. Conversely the hyphen may be used to prevent the indexing of certain words contained in multiple-word expressions. For example very-high-speed instead of very high speed. The references "see" and "see also" are readily exploitable and can be inserted in proper alphabetic positioning automatically by the computer while it is preparing the KWIC index.(65),(66)

5. The acronym "KWIC" is well chosen because it conveys the concept of speed. It is not extravagant to say that this system produces indexes more rapidly and accurately than any other form of indexing. Because of the speed of electronic data processing equipment, elapsed time between the date of publication of a document and its appearance in an index can be reduced from many months to a few days.(67)

6. A KWIC index system has the capacity of providing the users a double convenience in having an index in book form at their desks.

7. The establishment of categories and the assignment to such categories of index entries is a matter of judgment and experience and constitutes a considerable part of the intellectual effort involved in the

manual compilation of indexes. These and a whole host of indexing decisions inherent in any human indexing effort are eliminated by the KWIC index. Once the index is developed and in production, indexing can be done rapidly on a routine, essentially clerical, basis with the exception of adding descriptive words.

8. Printouts may have unlimited formats and may be reproduced for distribution by any convenient process, such as photo-offset.(68)

9. Generally, a KWIC index contains three sections as previously stated; the keyword index, a bibliography of documents, and an author index. Other sections may be added if desired, however. For example, corporate entries, lists of periodicals index, etc.(69)

10. KWIC indexing can be adopted to the literature of any scientific discipline, as well as to such areas as correspondence files, files of internally generated memorandums, legal papers, procedure manuals, etc.

11. Costs with respect to the preparation of a KWIC index are very encouraging. Kraft says that the approximate cost of producing a KWIC index containing 2000 titles on rented equipment is $580 per month. Naturally on in-house equipment the cost would drop drastically. Kraft makes the comment:

> "The cost per article indexed is only 29¢. This compares most strikingly with the cost of manually indexing an article, which averages $4. ...Since each title will average six keywords, the cost per index entry is 5¢ (29¢/6)." (70)

C. K. Bauer, manager of the Scientific and Technical Information Department of the Lockheed Aircraft Corporation, Marietta, Georgia, claims that Lockheed's newly installed KWIC system which processes 150 new books, 1250

reports and 425 periodicals monthly and prepares monthly overdue notices, accession lists and financial reports saves the company $600 per month. Further, total run time in data processing for all outputs of the system is less than two and one-half hours per month, including taping, sorting and printing.(71) Materials from Mr. Bauer's system are exhibited in Appendix A.

C. Disadvantages

1. The most common objection to KWIC indexing is that titles are not descriptive enough. In view of the results of this and other studies, the author does not feel that this is a legitimate objection. KWIC is feasible in highly specialized fields; its wholesale use is not suggested. On the other hand, when a title is found to be non-descriptive, or not sufficiently descriptive, it may be repaired by the scant editorial effort of adding descriptors.

2. KWIC indexing does not index deeply enough. This is less a disadvantage than a limitation. Certainly KWIC's hands are tied by the title when it comes to depth of indexing. By design a KWIC index is a shallow index, and consequently it can not hope to compete with the likes of the ASM Review of Metal Literature. Each, the shallow and the deep index, serves a useful purpose.

3. A title will sometimes have adequate keywords but still cause confusion because it is not descriptive. For example, an article titled, "Fixed Points and Antipodal Points", which concerns topology, appeared in the American Mathematical Monthly in the 1963 issue and could just as easily have appeared in the Engineering Index or the Applied Science and Technology

Index. If this title were to appear in a KWIC index comparable to either the Engineering Index or the Applied Science and Technology Index it would cause confusion. The title, "Fixed Points and Antipodal Points", could easily be assumed by radio engineers - particularly one who was working in the currently active research area of the antipodal reception of VLF waves - to belong to an article about electromagnetic wave propagation. (72) Another title that could be confusing is "Ray Paths of Whistling Atmospherics - Differential Geometry:, that of an article on the propagation of radio waves. An editor, lacking sufficient subject-field expertise, would undoubtedly KWIC both titles and thereby generate "noise" in the system. But the total elimination of noise can not be achieved except at great cost. The author feels that titles such as these appear infrequently. Hence, the noise they generate can easily be lived with, at least until interested cognoscenti inform the editor.

4. Another objection to KWIC indexing is that bibliographic information must be in machine readable form, that is, must be punched on IBM cards. This of course is a drawback; however, the time and manpower required for, and the cost of this operation is low. Keypunching is faster than typing. Also, since bibliographic entries are in machine readable form, they may be used for other purposes, such as the preparation of library catalog cards, accession lists, etc.

5. Two objections which involve the format of the KWIC index are that it is not very readable and that too much of the title is chopped or lost. These objections involve programming and are easily remedied. One technique which is employed by the American Bar Foundation to make its Index to Current State Legislation more readable is shown in Figure 12.

PART II — KEYWORD INDEX

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Observe that the left portion of each entry is shaded grey to highlight the keyword column and that each keyword appears only once for quicker recognition. Figure 13 illustrates what can be done to remedy the chopped title problem. Here 103 characters instead of the conventional 60 characters is available for the title. "An analysis of the lengths of titles in a 4500 - article computer literature index of periodicals, books and proceedings showed that 30 per cent of the titles would have been chopped in order to produce a 60 character single line, but only 2 per cent of the titles were chopped by using a 103 character line."(73) The 103 character format is the obvious solution to the chopping problem.

Thus, objections regarding format are easily rectified.

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V. APPLICATIONS OF KWIC INDEXING

KWIC indexes are used in such a variety of applications, that it would be difficult to enumerate all of them. Donald Kraft, information retrieval expert of the IBM Corporation has summarized several uses. Kraft says:

> "KWIC indexes are used regularly by a number of companies and organizations. Perhaps the most well known is Chemical Titles, published twice a month by the American Chemical Society as a current awareness program. Each issue indexes approximately 2,800 titles of chemistry. Biological Abstracts use a KWIC index in each monthly issue. Bell Telephone Laboratories use a KWIC index to disseminate technical information to its staff. Trans-Canada Airlines indexes its procedural manuals with KWIC indexes. In January 1963 the American Bar Foundation began publication of a KWIC Index of bills enacted by the 50 state legislations. This current awareness service is published approximately every two weeks during the height of the legislative sessions. In July 1962 the American Bar Foundation published its first KWIC Index, Index to Legal Theses and Research Projects - 1960-1961. ...IBM uses KWIC indexes for its collection of marketing publications and procedure manuals as well as for indexes to current IBM research projects and computer program libraries." (74)

In a letter to the author dated April 20, 1964 Mr. Kraft mentioned additional applications of KWIC indexing. One of these called a "Responsibility Index", seemed especially novel. The index, used at IBM Headquarters, permutes the job titles of Headquarters personnel and instead of a reference code a man's name is used. "Consequently one can use this to determine who is responsible for what. ...The American Medical Association uses a KWIC index to the signs and symptoms of diseases in their publication entitled "Current Medical Terminology." Northwestern University, Department of Languages (Greek), used a KWIC index to study the writings

of Galen. In this example, the entire text of Galen was keypunched in a transliterated form and treated as if it were one title. The listing proved to be very helpful. Kansas State University produced a KWIC index called "Kansas Slavic Index", which is a transliteration of Russian sociological titles. In closing, Kraft mentioned the work of Professor Kenneth Janda of the Political Science Department at Northwestern University. Professor Janda, to the surprise of this author, has KWIC indexed 236 recent political science doctoral dissertations. The author assumes that these titles were edited but from Professor Janda'a index it is impossible to discern either the presence or amount of editing. Perhaps Professor Janda's political science index suggests an ever broadening scope of activity for KWIC indexing.

VI. CONCLUSIONS

The flood of research papers, scientific articles, government reports and documents of every description, which began with World War II and continues unabaited today, compounded by a multiplicative analysis factor (the number of analytics, extracts, index entries, etc. per document) has generated an alarming information morass. The morass per se is harmless fire consumes paper. The harm is in the result of the morass - the difficulty in processing and retrieving useful information. The severity of the information problem has sent librarians, documentalists and information scientists in quest of means to expedite the handling of literature. Dr. Dwight Gray of the National Science Foundation, who equates information retrieval with experimention, recently wrote "...the processing and dissemination of the results of research - that is of scientific information - is as integral a part of the total research sequence as experimentation is." He then concluded, "the prerequisite to a solution to this problem is realistic recognition of information dissemination as a blood brother of experimentation..."(75)

Science, at the appeal of the information handlers and given impetus by interested constituents and government funding, is applying mechanical innovations - notably today's newest breeds of lightning fast computers - to all aspects of the information handling problem. Clearly there are vast horizons for mechanization in information handling, for in any information storage and retrieval system there are only two tasks which are exclusively assignable to man - the choice of documents to go into the system and the final evaluation of the usefulness of answers by the user of the information.

In between these two points is a series of unit operations - all of which may be performed by human beings and some of which may be performed wholly or in part by various machines.

Within the analysis unit operation, science has applied machines to abstracting, extracting, classifying and with distinct success to indexing. And of the various forms of machine indexing none has been as successful and widely adopted as keyword-in-context indexing (KWIC), the subject of this thesis.

After traversing the deductive path to machine indexing and journeying along the path stopping in succession at a description of KWIC indexing, a study of the adequacy of titles as search tools, pros and cons, and most recently at applications of KWIC indexing, the reader might conclude that the author regards KWIC indexing as a panacea. Not so! KWIC indexing does not impinge on nor will it replace other modes of indexing, with the possible exception of the shallow alphabetic subject index. A cure-all it is not: but a new and efficacious weapon to attack the information problem it is!

The author feels that the following principal conclusions may be elicited from the preceding discourse of KWIC indexing:

(A) Titles are adequate search tools, particularly in highly specialized fields.

(B) KWIC indexing, despite the repairability of non-descriptive titles, is best suited for highly specialized fields.

(C) The KWIC index is useful for either dissemination or retrieval.

(D) "KWIC" offers many advantages, such as speed, ease of preparation, flexibility and cost, but few disadvantages.

(E) Any specialized library or information center, given sufficient funds, or direct access to the machines necessary for preparing a KWIC index, or both, should give serious consideration to initiating this mode of indexing.

And finally, a comment regarding the study of the adequacy of titles as search tools is appropriate. As stated earlier, several similar studies to test titles have been conducted in the past. However, their results are not readily comparable and suggest limited inferences. This is because these studies covered very specialized fields, i.e., medicine, law, etc. and were performed by different individuals using different procedures and criteria. The study in this thesis spanned science, engineering, economics, business, social science, public affairs and the humanities. It was performed exclusively by the author, thus eliminating inter operator error and, in the author's estimation, lending additional support to its results.

VII. FUTURE

In the future, new applications of KWIC indexing will appear with great frequency now that the advantages of this system have been demonstrated. If the information to be indexed can be described in roman letters, it can be handled by a computer by using a keyword-in-context program. As KWIC indexes become available in more and more areas of knowledge, it is possible that authors will bear in mind to an even greater extent the later retrievability of their papers when writing the title. At Bell Telephone Laboratories, to encourage further improvement in titling, its Technical Information Libraries recently prepared and distributed to more than 5000 of the Laboratories' scientific and engineering personnel a concise guide on choosing titles for their papers.(76)

W. W. Youden, data processing expert of the National Bureau of Standards, sees a bright future for computer-produced indexes. The author includes Mr. Youden's comment because it provides the desired prophetic note on which to end this thesis. Here is what Mr. Youden has to say on the subject:

> "The use of computers in the production of indexes will increase. By feeding the output of the computer into a photo composition machine there will be an improvement in both the quality of the printing and the size of the character set. Today, the entire cost of a computer run to produce one copy of an index should be less than the cost of keystroking the input. The facility with which indexes may be updated and the ease of selecting items for special bibliographies will result in the majority of indexes being computer produced before many years. As more and more keyword indexes are published the author's choice of title words will improve, which will lead to more and better keyword indexes. Because of the intellectual labor involved

it is unlikely that even with computers the amount of subject-indexing will increase greatly.

...The day can not be too far off when printed indexes to scientific and technical libraries will be available to the individual researcher at his desk at a reasonable cost." (77)

APPENDIX A

Lockheed Aircraft Corporation Materials

APPENDIX A

This appendix offers four examples of computer-produced outputs from the newly installed mechanized information service system at the Lockheed Aircraft Corporation, Marietta, Georgia. The outputs are: (a) an accession list announcing all information material received, prepared on Multilith stencils for large reproduction (see Figure 12); (b) a cumulative index of report numbers in lieu of a conventional card file, with a carbon copy for each information center within company (see Figure 13); (c) a mechanically prepared subject index (for each information center through carbon copy print-out process) in lieu of conventional card file, using a "Keyword-In-Context" title system (see Figure 14); and (d) a cumulative personal author index for books and reports in lieu of a conventional card file with a carbon copy for each information center (see Figure 15).

MATHEMATICS

R64-00002544 MATHEMATICAL MODELS FOR SYSTEM-ANALYSIS
O Z

AD 419609 AF INST OF TECH, WPAFB, OHIO.

513.83M966E ELEMENTARY DIFFERENTIAL TOPOLOGY
S

514.083P482E EIGHT-PLACE TABLES OF TRIGONOMETRIC FUNCTIONS FO
S R EVERY SECOND OF ARC

517.52H393M MULTILINEAR ANALYSIS FOR STUDENTS IN ENGINEERING
S + SCIENCE

517J13M MATHEMATICS FOR QUANTUM MECHANICS
A Z

MECHANICAL EQUIPMENT

621.822B628A ADVANCED BEARING TECHNOLOGY
S

MEDICAL SCIENCE

R64-00002308 THE EFFECTS OF TRANSIENT WEIGHTLESSNESS ON BRIGH
A Z TNESS DISCRIMINATION

AMRL TDR 64 12 CORNELL AERON LAB. INC. BUFFALO.

MEDICAL SCIENCES

R64-00002303 EFFECTS OF SIMULATED AEROSPACE SYSTEM ENVIRONMEN
A Z TS ON THE GROWTH OF SELECTED ANGIOSPERMS

AMRL TDR 63 131 BOEING CO. SEATTLE.

METALLURGY

R64-00002075 EFFECT OF POLYSLIP ON STRAIN-HARDENING IN ALUMIN
L Z UN SINGLE CRYSTALS

UCRL 11160 CALIF. UNIV. BERKELEY. LAWRENCE RAD LAB.

Figure 14: Accession List

METALLURGY

R64-00002156 L Z — PREPARATION + EVALUATION OF HIGH-PURITY BERYLLIUM
Q-81933-5 — FRANKLIN INST. LABS FOR RES + DEVL. PHILA.

R64-00002158 L Z — THE ANALYSIS OF FRACTURE SURFACRS BY ELECTRON-MICROSCOPY
D1-82-0169 — BOEING SCI RES LABS. SEATTLE.

R64-00002190 S — SOVIET-RESEARCH IN POWDER-METAL-MATERIALS * METALLURGY METALS
JPRS 17 887 — JOINT PUB RES SERV. NY.

R64-00002191 S — ARTICLES ON SOVIET POWDER-METALLURGY * METALLURGY
JPRS 18 407 — JOINT PUB RES SERV. NY.

R64-00002239 L Z — METASTABLE AMORPHOUS PHASES IN TELLURIUM-BASE ALLOYS
CIT TR 22 — CALIF INST OF TECH. PASA.

R64-00002362 S — SOME ASPECTS OF THE HYDROSTATIC PRESSING OF POWDERS
JPRS 18 407 — JOINT PUB RES SERV. NY.

R64-00002417 S — SOVIET-EXPERIMENTS WITH TUNGSTEN MOLYBEDNUM AND ALLOYS OF REFRACTORY-METALS * METALS
JPRS 17 955 — JOINT PUB RES SERV. NY.

R64-00002435 S — DEVELOPMENTS IN CZECHOSLOVAK POWDER-METALLURGY
JPRS 20 291 — JOINT PUB RES SERV. NY.

R64-00002437 S — POSSIBILITIES + PROBLEMS OF POWDER-METALLURGY IN THE DEVELOPMENT OF NEW-MATERIALS
JOINT PUB RES SERV. NY.

R64-00002445 S — METALLURGICAL PROGRESS-REPORT * CERAMIC-MATERIAL METALS
USBM U 1109 — BUREAU OF MINES. ALBANY. ORE.

CPR [illegible]

NUMERICAL INDEX

INDEX NUMBER	CONTROL NO.	INDEX NUMBER	CONTROL NO.
ARB 12126	R62-00008[illegible]40	ARD TR 02 003	R63-00005663
ARB 17509	R63-00007976	ARD 151	R63-00002964
ARB 20328	R64-00000961	ARD 152	R63-00002966
ARB 2731	R64-00000965	ARD 153	R63-00002965
ARB 9374	R62-00008045	ARD 211	R63-00003101
ARB 9374	R62-00008045	ARDC TR 57 20	R63-00005152
ARB 9470	R64-00000964	ARDC TR 59 66	R63-00002932
ARB 9540	R64-00000963	ARDC TR 59 66	R63-00002110
ARB 9701	R62-00008046	ARDC TR 59 66	R63-00002258
ARB 9701	R62-00008046	ARDC TR 59 66	R62-00008351
ARB-10941	R62-00008032	ARDCTR 59 66	R62-00008350
ARB-10941	R62-00008032	ARF B 183 13	R63-00004327
ARB/292	R63-00001922	ARF B183 13	R64-00003065
ARC CP = 619	R63-00007804	ARF B241 4	R63-00006497
ARC CP = 620	R63-00007805	ARF B241 6	R63-00008141
ARC CP = 627	R63-00007807	ARF B765 26	R63-00007009
ARC CP = 642	R63-00007806	ARF IPR = 1	R63-00007308
ARC CP 10[illegible]	R64-00002215	ARF PR 7	R63-00003294
ARC CP 129	R64-00002275	ARF PROJ D118	R63-00002391
ARC CP 188	R63-00007408	ARF 1120 55	R63-00001685
ARC CP 358	R64-00002210	ARF 2211 5	R63-00001124
ARC CP 361	R64-00001470	ARF 2241 2	R63-00006490
ARC CP 645	R64-00002221	ARF 3209 12	R63-00000673
ARC CP 655	R64-00000882	ARF 3209 12	R63-00000673
ARC CP 656	R64-00002220	ARF 5134 8	R63-00003209
ARC CP 663	R64-00000846	ARF 5134 8	R63-00003209
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KEY WORD	TITLE	CONTROL
	CE-ABSTRACTS PROCEEDINGS	
ACADEMY	REPORTS OF THE ACADEMY OF SCIENCES OF USSR PHYSICAL CHEMISTRY (SELECTED ARTICLES)	R64-00
ACCELARATORS	1963 SUMMER STUDY REPORT PART ONE SUMMER 1963 • ACCELARATORS NUCLEAR-PHYSICS	R64-00
ACCELERA	PHOTOELECTRIC EARPIECE RECORDINGS • OTHER PHYSIOLOGIC VARIABLES AS OBJECTIVE METHODS OF MEASURING THE INCREASE IN TOLERANCE TO HEADWARD ACCELERA	R64-00
ACCELERATING	THE ACCELERATING EFFECT OF ADDITIVES ON RADIATION-INDUCED GRAFT POLYMERIZATION • SOLVENT-ACTION	R64-00
ACCELERATION	VESTIBULAR SUPPRESSION • ACCELERATION	R64-00
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ACCEPTANCE-PROBABI	SINGLE SAMPLING INSPECTIONS-PLANS WITH SPECIFIED ACCEPTANCE-PROBABILITY + MINIMUM-COSTS • PROBABILITY	R64-00
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